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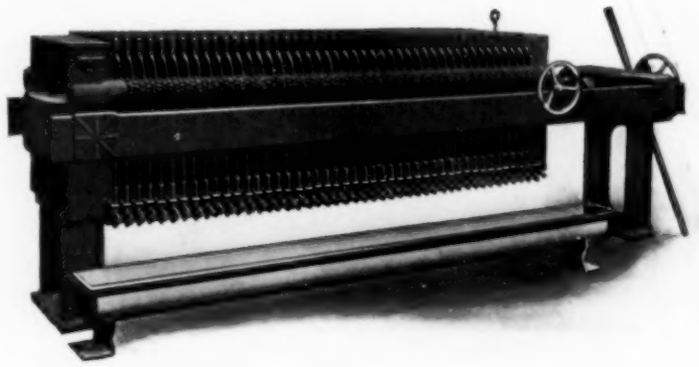

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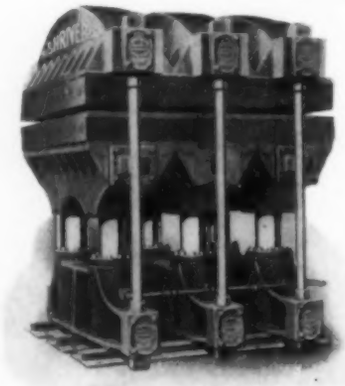

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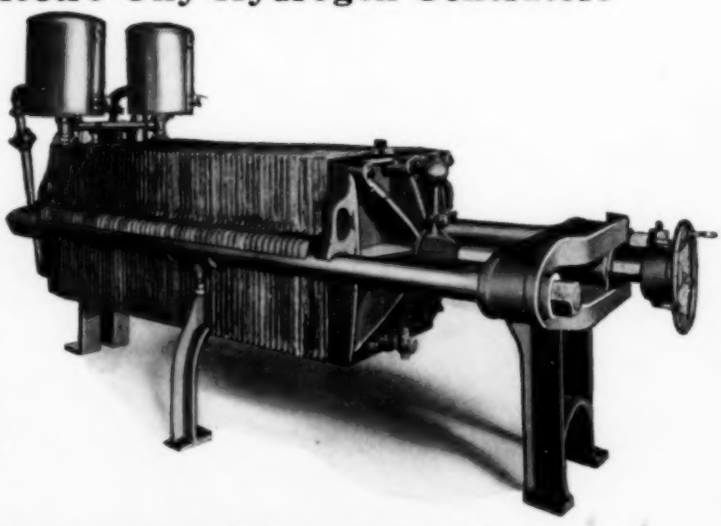

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Industrial Peace

This country has suddenly become involved in a double war. Besides the war with Mexico we have the civil war in the Southern Colorado coal fields. While this journal is neither a mining paper nor a coal paper, the Colorado civil war is of such broad significance for our whole industrial life as to require comment.

We do not dispute in the least the wisdom of the operators to refuse to arbitrate the right of non-union men to work. But we seriously doubt their wisdom of refusing in the beginning any mediation whatsoever when besides the fundamental union principle, some five other points concerning the eight-hour working day, wages, etc., were at issue. It seems to us that then and there the operators lost a splendid opportunity to secure by diplomacy the moral support of the public.

Men are changing and things can no longer be run as they were run twenty or ten years ago. The president of a large public service corporation who recoined a famous old phrase into "The public be pleased" read the signs of the times correctly. In this new age made by the peaceful work of the engineer, only such policies can and will succeed as make for satisfactory relations between employer and employee for satisfactory relations between investors, utilities, and the public—for industrial peace.

Copper Hydrometallurgy at Chuquicamata

Interest in copper hydrometallurgy justly centers in the work of the Chile Exploration Company at Chuquicamata, Chile, and the interesting experimental work which has been carried on in this country for over a year under the direction of Mr. E. A. Cappelen Smith. In studying Mr. Smith's description of the Chuquicamata copper deposits and the metallurgical investigations thereon, which we present on another page in this issue, the reader will be struck with the element of scientific, as well as financial, adventure which surrounds the past and future of this project.

Truly, a tremendous task has been assigned to metallurgical engineering. Responsibility for the expenditure of millions is imposed on a comparatively small group of engineers, in whom, also, the investors place their hope of financial success.

It may be argued that all mining and metallurgical schemes are, or should be, similarly conceived and executed, but in this instance we find some unusual factors. Precedent cannot guide; ingenuity must point the way; reliance must be placed on comparatively small tests; foresight must meet unusual conditions in a foreign land that is far distant from centers of

manufacture and supply. In short, every detail must be worked out and proved successful here before it can be applied there.

And yet the thought presents itself that there are some elements in a venture of this kind that cannot be ascertained with absolute certainty, but only within limitations. Thus, only 600 tons of Chuquicamata ore have been treated experimentally in this country. The ore developed at the mines amounts probably to oved 200,000,000 tons. How truly representative of the ore-body is the quantity tested? We may assume that it is as representative as engineering skill could make it; and yet it does not compare in quantity with the amount of ore treated experimentally by, say the large copper companies in this country, before they settled definitely on their scheme of treatment and erected large mills. Six hundred tons of ore is not a large test-lot. Inspiration has prepared to treat that much per day in an experimental mill for concentration and flotation—processes that are reasonably well known and successful elsewhere.

This illustrates fairly the exceptional features of the Chilean project; probably it was more expedient to bring a small parcel of ore to a test plant conveniently situated, than to erect an experimental unit at the mines.

Other features of metallurgical adventure in the Chuquicamata project are found in the problems that called for original solution. The removal of chlorine from the copper solution, the selection of suitable anode material, the acid-proofing of concrete vats, and the mechanical methods of handling large quantities of ore, all presented interesting subjects for research. Apparently they have been dealt with successfully, and in a comparatively short time.

Not the least point of interest in the whole matter is the evident change in the attitude toward copper hydrometallurgy as evidenced by the magnitude of the project and the spirit with which it has been undertaken. Mr. Smith has been confronted with a problem which, in point of magnitude and novelty, has never been undertaken before. He has the best wishes of the metallurgical fraternity for the ultimate success of the venture.

Federal Mining and Metallurgical Legislation

Until the Mexican situation demanded practically its entire attention, Congress exhibited signs of activity in legislating for the mining industry. The Senate was considering a bill to codify and suggest amendments to the general mining laws, and the House was concerned with a measure providing for the establishment and maintenance of metallurgical experiment stations. It was hoped and expected by the sponsors for these bills that they might be passed at the present session of Congress. As the bills stand it is doubtful if their provisions are wholly wise. They are open to serious criticism.

Sentiment among engineers and operators is generally favorable to a revision of the mining law, and the leading mining and metallurgical societies have had excellent committees working on suggestions. The present mining law was based on the knowledge of the science and art of mining many years ago. Since that time our knowledge has increased many fold; mining geology has revealed many new facts; general mining experience has proved the deficiency of the old law.

For the purpose of revision the Senate proposes the appointment of a commission of three members; two of whom shall be lawyers experienced in the practice of mining law, and one a mining engineer of practical experience in mine operation. It seems to us that this proposal is typical of legislation conceived by men not fully in touch with the practical conditions in the industry; and we believe that we voice the sentiments of many engineers when we suggest that this commission is not large enough and that there should be a preponderance of mining engineers and geologists instead of lawyers. The latter will be indispensable in properly framing the changes which the former suggest as a result of their knowledge and experience in mining; but the burden of suggesting changes naturally falls on those conversant with actual conditions. Therefore, one engineer is not enough; there should be at least three. These, with two lawyers, might reasonably expect to report amendments that could be adopted with the least disturbance in the industry.

In regard to the bill for metallurgical experiment stations, the features can be briefly stated as follows: Ten "mining experiment stations" are to be established in the United States and Alaska, under the control of the Secretary of the Interior. Each station is to be in charge of an engineer and a metallurgical chemist who shall receive annual salaries not exceeding $4,000 and $3,000, respectively. Each station is to receive an annual appropriation of $25,000 to buy supplies and equipment, and to pay salaries. The Secretary of the Interior may accept contributions of land, buildings, supplies or money from states desiring to cooperate with the Government in the establishment of these stations. Each of the stations, under the direction of the Bureau of Mines, shall make investigations in the mining and treatment of ores, with a view to increasing efficiency in methods and preventing waste, and shall disseminate practical information on these subjects.

A serious objection to this bill is the division of funds. An annual appropriation of $250,000 for the Bureau of Mines is a matter very different from appropriations of $25,000 each for ten experiment stations. Under the provisions of the bill there will not be enough money available for any one station to enable it to carry on serious investigations of any consequence, and there must inevitably be a duplication of work. In other words, the total appropriation will be spread out so thin as to be of little value; it will be consumed largely in maintenance and salaries. Under these conditions it is doubtful if the Government could produce appropriate results.

Perhaps the framing of the provisions of this bill is dictated, to some extent, by political necessity. In order to secure support for the expenditure of such a large sum of money, the appropriation is scattered over a large area and divided among a number of states. This may be good politics, but we believe it is not in the best interests of the industry. If funds are to be provided for mining and metallurgical investigations, they ought to be concentrated instead of scattered.

A Change in Engineering Education

Columbia University announces a change in the conditions for admission to its engineering schools. Candidates will be required to present evidence of preparation in general educational subjects equivalent to three years' study in the regular college course. Such a procedure has been done already at Harvard and is similar to German custom. This is what is required of the candidates for law and medicine and is a recognition of engineering as a profession of the same dignity as law and medicine and requiring much the same educational foundation. With the splendid facilities offered by Columbia this raising of the standard will give us an engineering school of as high a rank as any in the world. At Harvard the graduates receive the title of Doctor of Engineering.

The effect of this on the profession cannot be other than good. Of course, there will always appear occasionally a young man bound to acquire an education while engaged in practical work, as Abraham Lincoln made himself master of his profession without any educational advantages. If another John Fritz should be born he would be John Fritz still, even if he never earned an academic degree, just as Faraday was a great physicist and electrician by nature. It is possible that men of this type would not be helped by a technical education; indeed, some psychologists hold that they would be injured by making the initial steps too easy. But they are exceptional, probably we shall see only a few in a century, and educational institutions are intended for the general run of mankind. Again, there will always rise from the ranks men of executive ability, who pick up a scientific knowledge in the hard school of experience, and make invaluable superintendents or managers. Such men are entitled to be called engineers even if they cannot write two letters after their names. Such men, too, are not common, for executive ability is a gift of the highest value if combined with common sense and a kindly disposition.

Now the great body of men need training in theory as well as in the school of experience. Columbia will furnish a technical training of high grade, and it is wise to base this on some general culture, so that an engineer with a degree of Doctor of Engineering will have a working knowledge of at least one foreign language, an ability to write plain and forcible English, and a habit of taking broad views, created by some economic and historical study. On a cultural foundation it is intended to build professional training, and when to this professional training is added ten years of practical work her graduates ought to prove good all-round men and some of them engineers of a high grade. To repeat: there are some men bound to forge to the front in the engineering and in any other profession without much aid from educational training, but the great body of men must be trained early and started right. This, modern education proposes to do, merely insisting that the young men she teaches shall come to her with a knowledge in outside subjects equivalent to what they would acquire by three years of college. Then she will teach them more in a year than they could learn in five in the rough and tumble of practical work.

Many graduates of professional schools never follow up the profession; for instance, an opening in a patent lawyer's office may give one an opportunity and he takes it. Some graduates of the engineering schools will doubtless drift into other employments. A well-trained engineer can easily become a patent lawyer. Conversely a patent lawyer should know more than he usually does about engineering. The big cases turn on engineering questions. The engineer also sometimes makes a good business man. But the great benefit of an education not used for its earning capacity is that it gives an interest in life. To an engineer a mine, a smelter, a machine shop, an electrical plant, are objects of the highest interest, as much so as forest is to the trained forester. The more he knows, the keener his interest, and to take an intelligent interest is really to live, and to produce results.

There is a peculiar fitness in making Columbia the center of a great technical school. Its first president, Samuel Johnson, a great Hebrew scholar, was a friend and admirer of Benjamin Franklin, who had an influence on him and Columbia. He conceived the idea of having what was then called "natural philosophy" taught in the college which he was founding. The correspondence between the two shows the interest felt in electricity at "King's College" even at that early date. Neither of these men could have imagined that this germ should grow into the School of Mines and later into the three great affiliated schools of science which are now to be raised to a higher plane. The methods of teaching science have developed as rapidly as science itself, to which "the Arts" so long revered as the acme of education are now to furnish a preliminary training.

The Wage Problem in the Steel Industry

The wage problem in the steel industry is peculiarly complicated. The problem has its practical, its economical, its technical, its sociological and even its legal aspect. To speak of the legal aspect of a wage problem may seem strange, when there are no contracts to speak of between manufacturers and men, yet there is undoubtedly a legal aspect to this problem. The United States Steel Corporation, which makes approximately one-half the steel in the country, is defending a suit brought in October, 1911, for its dissolution, so that it is practically fighting for its very life. In its defense it has cited its liberal, enlightened and pro-

gressive treatment of its employees as one of its *raisons d'être*. It can be cited as a fact that the management of the steel corporation is strongly opposed to wages being reduced. It would be unfair, and we believe entirely incorrect, to infer that the pendency of the dissolution suit has anything to do with its attitude; but it is perfectly fair to hold that were there no other considerations the management would be justified, as men commonly look at things, to avoid a wage reduction when its conduct is being scrutinized from the standpoint of the common welfare. In another respect the wage problem has a legal aspect, for when it developed recently that a number of independent steel manufacturers had conferred in Pittsburgh relative to the advisability of reducing wages, a resolution was promptly introduced in Congress that the subject be investigated.

Experts in steel market conditions and movements insist with one voice that a reduction in wages would not widen the margin between production cost and selling prices. The steel market is wide open and strongly competitive, presenting a contrast to conditions which prevailed frequently prior to 1911, and the opinion is strongly expressed that a saving through a wage reduction would immediately be given away to the buyers of steel, the only effect upon the volume of business being to delay buying until buyers became assured that the full measure of the saving in wages was written into market prices. Thus from the practical or commercial viewpoint the question of reducing wages may be dismissed without further discussion.

From the economic aspect the problem is a much more difficult one. Two things usually are granted, that the division between labor and capital in manufacturing should be equitable, and that wages should be arranged with reference to the cost of living. When applied to the steel industry, however, these principles have opposite applications. Selling prices of steel are extremely low. They are but slightly above their historic low point of the late nineties and the subsidiary low point reached somewhat more than two years ago. They are very far below their high points of 1899, 1902, 1906-07 and 1909-10. Indeed, in all the past the tonnage sold at prices lower than those now prevailing is an insignificant percentage of the total tonnage which has been produced. The present wage rates, however, which date from the general advance of February, 1912, are the highest ever paid. According to the principle of equitable division between labor and capital, wages should now be reduced. But according to the other principle, involving the cost of living, they should not be reduced, for the last advance was based upon an increase in the cost of living and there has not since been any measurable decrease in that cost. By reason of these divergent showings, the study from the economic aspect gives no clear suggestion.

The sociologic aspect gives much more promise, but is clearly much more difficult for analysis and judgment. The procession of workmen through the iron and steel mill gates has changed in nationality time after time, but at all times the great mass of the labor has been composed of the more recent immigrants. For decades the American-born workman has been in the minority at the coke works and blast furnaces and in the iron and steel mills. The most cursory study shows it inconceivable that under present working conditions a change can occur in the direction of the American-born constituting a larger proportion of the working force in the industry. As the foreign-born die and the industry grows in size immigration must expand or working conditions must be changed so that American-born labor is attracted. Clearly it is a matter of serious import whether the United States should welcome to its shores increasing numbers of men who are content to do work which our own native born refuse to do. Apart from this sociologic aspect it is very pertinent to inquire, from the practical standpoint, whether it will continue to be possible for the industry to attract the immigration. With each of the countries which has in the past supplied us with so much of our population the movement to the United States has been more or less temporary. In turn, as conditions in their respective native lands improved, the men have been influenced to stay at home. Nor does it follow that if one emigrates he must come to the United States. In recent years there has been an important movement to South America, and year by year the amount of work which South America should and can do increases.

Whether the problem be to ensure a continuance of the flow of immigration for the maintenance of the iron and steel industry, by making the employment attractive, and at the same time make better men of the immigrants, or whether the problem be to attract American-born labor, the problem is a technical one, in that it involves the character of the service to be performed by the workmen and the conditions in which the service is performed. For this reason we included the technical as one of the different aspects in which the question of wages in the steel industry should be viewed, and in many respects the aspect is the most logical and promising. In the past few years the steel manufacturers have fully recognized the importance of improving working conditions, and encouraging a better home life. Millions of dollars have been spent along these lines and the disposition to effect these improvements grows as it is exercised. Despite these rapid improvements, however, the labor market has not been surfeited, but one finds rather that in recent years the periods of labor scarcity are more pronounced and the periods of unemployment are less marked, than was the case in the past.

It has been recognized by the sociological workers that seven-day labor, and apart from that twelve-hour-a-day labor, are undesirable from their standpoint, but a fact which these workers do not always recognize is that the workmen have opinions of their own. Not very long ago the United States Steel Corporation abolished seven-day labor in its plants, and the statement was made by Chairman Gary at the annual meeting of the stockholders April 20th that upward of 4000 men left the corporation's employ by reason of the change. The number of men who had been working seven days a

week was not stated, but it is well known that it represented only a very small proportion of the total number of men employed by the corporation, so that the number of men who left must have been a very considerable proportion of the total number affected. There remains the twelve-hour day, with respect to a very considerable proportion of the men employed in the steel industry. As is well understood, the men do not actually labor during more than about two-thirds of the twelve hours during which they are technically on duty. There does not seem to be any particular reason why the service they perform should be reduced, but there are reasons which would make it advantageous for the work to be concentrated into a shorter period, whereby more time at home would be allowed. This is a technical question in works management. It has been very seriously considered already and is admittedly a very difficult one. It is a problem which must in nearby years be solved, though it certainly cannot be solved over night; but it is so important that the question of current wage rates cannot be approached without full reference to it.

The Tango of the Electrochemists at the Chemists' Club

"And David danced before the Lord with all his might,—girded in a linen ephod."

We have often remarked in these columns that the great law of harmonic motion holds in other lines than that of pure physics. For example, the ebb and flow of material prosperity from boom times to hard times seems to follow with almost mathematical precision the same course as a pendulum. Individuals, too, are elated then depressed. Philosophy of one age is materialistic, of the succeeding age spiritualistic. So Fourier's series may be found to pervade the great world of men, women and things.

While it takes something more than Fourier's theorem to analyze any social change exactly, yet it must be apparent that the world now looks lightly on forms of amusement that formerly were condemned as vulgar, and the Puritanic notions of what is right and proper are being replaced by views Hellenistic in character. In short, the Greek pagan pantheistic idealism is being superimposed on our social structure. There are many evidences of this replacement. The prevalence of amateur and professional sport in daily interest, the freedom of dress that women are assuming, and finally the modern worship of Terpsichore that is increasing everywhere in the world are merely signs of the times. It was only a half a century ago that round dances were socially taboo and the advent of the waltz, polka and two-step was beset with vain remonstrances from society's mentors. This is remarkable but it is a fact.

The so-called modern dances growing so fast in popular delight are having a similar reception. They are, however, a perfectly natural concomitant of changes in other directions and have a clearly recognizable cause. This cause is natural physical relaxation that is needed after mental work. All intellectual or imaginative effort produces an effect on the sensory and motor centers of the brain. This is exerted harder and in more directions than heretofore because of intensity of modern thought. We can also adduce the theory that the thought centers of the brain are but glorified sensory or motor centers and that the former bear some relation to the latter as does the blossom of a plant to the leaf or as the cranium does to a vertebra. It was Goethe who pointed out first that the blossom was simply an extended and transcendental leaf and that the cranium was a development by functional evolution of the simple element of the backbone.

Accordingly, if we admit the theory that Goethe's discovery applies to the human brain, then on psychological grounds and also on physiological grounds, dancing of the tango or maxixe is due to the fact that the individual has had his thought centers greatly stimulated by many new things, and this calls for a balancing of his faculties by stimulation of the lower centers. Probably no better way for muscular exercise can be devised than dancing and probably in no way can the motor centers of the brain be better stimulated than by dancing. The great modern advances in thought, in art and in science produce marked effects on each and everybody's mind—mental displacements that, unless counterbalanced, can effect a permanent astatic mental condition. It is a rational procedure, therefore, to relax as in the present fashion in dancing, for the graceful movements of body to music produce a harmonic balance of motor centers and cause a normal return to equanimity. This is especially true if we admit the extension of Goethe's hypothesis of the glorification of an organ by its assuming a new function, for in that event the thought centers and motor centers are directly connected and no surer means of easing the former could be chosen than by easing the latter. Whether the modern dances are hurtful or vulgar depends entirely on how far the sex quality present in most forms of dancing predominates in both the conscious and unconscious mind, and that is entirely a question of individual self-restraint and good sense.

We can but admit, therefore, that the reaction from the Puritan notion that because a thing is pleasant, it is necessarily wrong, is a perfectly natural one and that the extension of human activity in a light and fantastic manner is normal and sound. The relation between dancing and religious activity as evidenced for example by the dancing dervishes or Shakers—"David danced before the Lord"—is a collateral line of thought. But what would the Calvinistic divines of the colonial period, such as Jonathan Edwards, have said to the tango or turkey-trot? Neither the sine curve nor signs of the times would have availed as an explanation to such worthies. The dance of the electrochemical scientists and engineers at the Chemists' Club would have been anathematized. But to them it was the charming finale of a glorious convention.

Readers' Views and Comments

A New Design of Filter Press

To the Editor of Metallurgical & Chemical Engineering:

SIR.—Having recently arrived from Australia, I have just seen the article in your February issue, entitled "A New Design of Filter Press," by Alfred Burger. If I understand the description aright, the same idea was put in practice at the Victoria Mill of the Waihi Gold Mining Company, New Zealand, when I was there in 1901. It was used to wash slime (200 tons per day) in Dehne and Martin filter presses after cyanidation, was invented by Mr. H. P. Barry, the superintendent, and was known as the "central wash." I believe it was also used at some of the mills at Kalgoorlie, Western Australia, about the same time.

San Francisco, Cal. W. MOTHERWELL.

Value of Research Work

To the Editor of Metallurgical & Chemical Engineering:

Sir:—When the Wright brothers were experimenting with their gliders they were considered as "eccentric nuts" with a mania for flying. Nobody doubts now the fuuture commercial value or possibilities of the aeroplane.

Henry Ford was the target for ridicule in Detroit when he was "monkeying" with his first model. A few years later when cars were pretty reliable, although considered an expensive luxury, a very prominent business man was heard to remark that they might be a toy for the rich but they would never be used for trucking or other commercial purposes.

The above wellknown examples are typical of many other cases which have and will open fields of untold wealth to society. Many manufacturing institutions produce more wealth than gold mines for an equal amount of capital invested. This great earning power was made possible by the plodding research of some pioneer who single-handed had courage enough to venture out a little and match his starving along against his possible success. Then the miserly pittance that some of these same large firms give to further research work should shame their narrow grasping methods.

A prominent railroad after having been plundered time and again by financial pirates was in the receiver's hands. Then and not till then was an attempt made to improve the efficiency of the road. Now real road tests of the locomotives are being made by test cars placed between the locomotives and the train. The advice of the efficiency engineers will no doubt be followed and the earning power of the road will increase, the large as well as the small leaks will be stopped, and the road will get back on its feet again. Why should it be necessary for a railroad to get into a receiver's hands before steps are taken to increase the general efficiency and earning capacity of the road by employing efficiency engineers and experts to do research work?

A few of the larger concerns are spending many thousands to build and equip experimental laboratories to carry on experimental work along their particular line and find that it pays extremely well. Many others have contributed to The Mellon Institute of Industrial Research for scholarships. This manner of promoting investigation along new lines has proven very satisfactory to all concerned. For this method of providing means to carry on research work we are indebted to the foresight of the late Robert K. Duncan.

People are hunting to the farthest corners of the earth for radium bearing ore, especially since prominent authorities claim its value in the treatment of cancer. Thousands of dollars are being spent in this search and justly so. Money carefully spent in developing new industries or in improving old ones is likewise well spent and yields a wealth to society which cannot be estimated.

C. J. BARTON.

Chicago, Ill.

The Technical Parasite

To the Editor of Metallurgical & Chemical Engineering:

Sir:—Parasites are found in all walks of life and in all phases of human activity. They are as conspicuous in the technical world as elsewhere. The technical parasite is generally in the employ of a large manufacturing concern. He attends the meetings of scientific and technical societies, and even condescends to serve (?) on technical committees. While papers are being read or discussed he generally remains silent, seldom responding to an invitation to contribute to the discussion, more rarely still volunteering any information. His food consists chiefly of the crops laboriously raised by others and of this he partakes copiously and, if perchance he succeeds in raising a little himself, he guards it zealously for his own consumption. Notwithstanding this parasitic feeding, his attitude, instead of being one of humility and thankfulness, is often critical, not to say arrogant.

As a member of technical committees his work is seldom constructive. It is obvious that his interest in the labor of the committee ends when, in his judgment, it ceases to benefit him. He is secretive as to whatever information he has or fancies to have. While eager to receive, he is ever reluctant to give. He would even prevent the dissemination of knowledge likely to benefit others as it benefits him. He frequently affects to be the wise possessor of knowledge not available to the other members. This little game flatters his vanity.

What is there to be said in defense of the technical parasite? Certainly his vision is limited to the monetary value of his technical knowledge. He is unable to grasp the greater meaning, greater duty, and greater reward attached to a more lofty conception of the services owed by technical scientists to their fellow men. He apparently believes that he is serving the best interests of his employers—that his parasitic habits make him a more valuable man. In this egotistical attitude is he not misguided, even from a purely sordid point of view? To begin with, the exclusive knowledge he fancies or affects to possess is too often a mere *secret de polichinelle*. There are those who believe that a freer and more generous interchange of thoughts and information among technical men commercially engaged would promote progress in a way that must necessarily prove of much benefit to them. It is far from demonstrated that modern business, to be successfully conducted, is dependent on Chinese walls erected and guarded by technical parasites. It is now quite generally admitted that honesty is the best policy, in spite of the immediate returns which are seemingly within reach

of the dishonestly inclined. Let us hope that the time will also come when the policy of free interchange of thought and knowledge will be recognized as the best policy by those sordidly inclined, in spite of the apparent gains to be derived from a parasitic policy.

Personally the technical parasite may be a very good fellow, but as a member of the great industrial, technical fraternity he is worse than useless. For my part, I should welcome the discovery and effective use of the exterminating bug that would put an end to his parasitic existence. X. Y. Z.

Cambridge, Mass.

Central Research Organizations

To the Editor of Metallurgical & Chemical Engineering:

Sir:—The editorial re "Central Research Organizations" in your April issue prompts the comment that "research" being "invention," in its full development must utilize the strongest types of individuality, be controlled by personality and conducted by minds not essentially business.

The commercializing of the "research" idea as developed by personality may be possibly best conducted by a central organization, but the inventive ideas of great value can never be directed, controlled, or produced under organized effort. Invention is spontaneous like poetry, music and art.

Education helps, if not carried so far as to destroy originality.

Apparatus and finance are absolutely necessary especially in metallurgical work where volume is so necessary to prove or disprove a theory.

The same experiment may appeal to different minds very differently. The fact that one investigator sees only failure does not prove that another may not see success. It is best that the successful man does not know of all the failures of the unsuccessful or is not advised in the direction of his tests because of the failure of others.

Research can most efficiently be conducted under small units dictated solely by original personalities not connected in any way with commercial minds.

As results indicating industrial value are produced, the business mind or organization should take control, and it is to such organizations that research must look for all its finance, since its only product consists of merchandise that can be sold or utilized only by organized capital. To centralize research would be to suppress it in its highest development. However, the thought is unlikely of realization any more than the thought relative to the centralizing of poetry, music, or art.

PARKER C. CHOATE.

National Lead Co., Brooklyn, N. Y.

A New Source of Zinc Ore

To the Editor of Metallurgical & Chemical Engineering:

Sir:—The recent discovery of a deposit of calamine at Embreeville, Tenn., furnishes us with additional proof of the elusive nature of the silicate and carbonate ores of zinc.

The new deposits are found on the property of the Embree Iron Company, Embreeville, Tenn., 11 miles from the main line of the Southern Railroad, being reached by a branch line from Johnson City. This property has been worked in the past for the rich deposits of hematite which it contains. A blast furnace with a capacity of 200 tons was erected in the late '80's, and was in operation intermittently until 1908 when it was blown out.

Throughout the whole period of its activity it was known that the ore being fed into the furnace contained amounts of lead and zinc, though no one seems to have suspected the presence of any great amount. At times they experienced considerable difficulty in making the furnace function properly, partly due to the excessive amounts of zinc and lead in the burden.

The hematite was mined by hydraulic methods which partly explains the reason why such a small amount of zinc-bearing ore found its way into the

FIG. 1—OPEN CUT IN CALAMINE DEPOSIT, EMBREEVILLE, TENN.

charge, for the calamine lies underneath the overburden of soil and hematite.

Geologically the hematite and calamine lie in the Shady limestone, a Cambrian formation, along with the residual clays of the same formation, locally called "buck-fat." The calamine is found massive, that is, in lumps, in thin "stringers," and in granular form, all more or less mixed with the hematite-bearing soil, limestone, and "buck-fat." The associated minerals are hematite, galena, smithsonite and small amounts

FIG. 2—ERODED PINNACLES OF SHADY LIMESTONE FORMED BY HYDRAULICKING FOR HEMATITE

of cerussite and sphalerite, the latter mineral only in the limestone. The limestone is a dolomite, approximate $2CaCO_3.MgCO_3$.

The mining of the ore is carried on by means of open cuts and pits, the deeper deposits by tunnels and top-caving through "thunder-holes." The bottoms of the cuts have a gradient sufficient to allow tramming to be done by gravity.

The ore is hand-sorted in the cuts, the barren soil, limestone and clay being separated as far as possible from the zinc ore. The former products go to the "muck" pile, the latter to the washer to be treated. Temporarily the ore is being treated in a log-washer and a dry-house.

The mine cars run to a tipple on a trestle and dump on a grizzly with 3-in. spaces between bars, where it is washed with a spray from a nozzle. The oversize goes directly to the dry-house. The undersize discharges by chute into a 30-ft. double log-washer of the Longdale type. From the washer the washed material passes to a bucket elevator which discharges on a picking belt. The slimes pass to a slime pond.

On the picking belt the iron ore, limestone and country rock are picked, the zinc ore passing to a bin in the dry-house, from which it discharges to a tram-car and thence to the floor of the dryer.

The dryer is a structure 20 ft. by 120 ft., drying ore from 20 per cent to 5 per cent moisture at the rate of 30 tons per 24 hours. The finished product has the following approximate composition: Zinc, 33-38 per cent; iron, 11-15 per cent; moisture, 5-10 per cent.

H. A. MERENESS.

Embreeville, Tenn.

Blast Furnace Blowers

To the Editor of Metallurgical & Chemical Engineering:

SIR:—In a very interesting article by Mr. J. E. Johnson, Jr., in the April number of this paper nothing is said about the use of the centrifugal compressor on the iron blast furnace. Mr. Johnson's many years as a practical blast-furnace operator entitles his opinion to especial respect. It has occurred to the writer that a brief discussion of the results obtained from this comparatively new style of blower, when operating on the iron blast furnace might be of interest. It seems to be conceded that the following points of contrast between centrifugal and reciprocating blowers may be set forth.

(a) Mechanical Efficiency.—This is much higher with the reciprocating type than with the centrifugal —probably 90 per cent or more with the former—while with the latter probably not much in excess of 70 per cent.

(b) The Volumetric Efficiency.—This is usually quite high in the reciprocating type, due to skillful design as indicated by Mr. Johnson. As a general rule, the volumetric efficiency is higher than the mechanical efficiency in a reciprocating blower. However, it is apparent that any leakage due to worn or cracked valves, etc., will easily reduce the volumetric efficiency. On the other hand, it is claimed that the *initial* efficiency of the centrifugal blower, while relatively lower, is maintained indefinitely, owing to the fact that there are no rubbing parts except the rotor bearings. A slight clearance is left between the impeller tips and the guide vanes.

(c) The Item of Inertia is Important.—Mr. Johnson has shown some of the reasons for engines "pounding." This is not a feature of the reciprocating type, necessarily, but it is harder to eliminate than with the centrifugal type which may be nicely balanced. The writer has seen a single-stage centrifugal blower delivering 40,000 cu. ft. of air per minute at a discharge pressure of 4 lb. per square inch, with coins balanced on edge, on the casing.

(d) Head Room.—The economy of space required for housing is greatly in favor of the centrifugal compressor.

(e) The "Over-all" or Net Efficiency of the Blower and Its Driving Unit.—The practice of using reciprocating blowers with internal-combustion engines has been generally adopted. Its advantages are apparent. The subject is ably discussed in detail elsewhere by Mr. H. J. Freyn[1] and others.[2]

With the centrifugal compressor it is necessary to use high-speed drive, viz., a motor or steam turbine, either necessitating the generation of electric power in the gas-electric generator, or else steam in the boilers, using the blast-furnace gas. In either event, thermal losses occur.

It has been stated that the economy of the steam turbine-driven centrifugal unit is enough higher to warrant its replacing gas-driven reciprocating blowers.[3]

While this may hold in certain special cases, it would appear to be doubtful as a general statement under present conditions.

Automatic regulation of blast volume is a feature of the centrifugal type which is attractive. The crux of the matter is an economic one and appears to lie with the question of the driving unit. The perfecting of a gas turbine with high thermal efficiency may place the centrifugal blower abreast of the reciprocating blower for blast-furnace work.

C. E. MCQUIGG.

State College, Pa.

The Western Metallurgical Field

Brown Cyanide Process Decision*

In the issue of METALLURGICAL AND CHEMICAL ENGINEERING for October, 1913, page 541, we commented on a decision of the United States District Court for the District of Delaware, in the case of Joseph A. Vincent vs. Tonopah Mining Co., et al. This suit was brought by Mr. Vincent as owner of patent 781,711, granted to Alden H. Brown Feb. 7, 1905, in which the patentee claimed invention of a process involving cyanidation followed by concentration. The Tonopah company was sued as infringing the patented process, and the District Court so held. Appeal was taken by the defendant to the United States Circuit Court of Appeals for the Third Circuit, which has reversed the original decree and remanded the case to the lower court with instructions to dismiss the bill for non-infringement.

Our comment at the time of the first decision was to the effect that we believed the patent could not be sustained in many cases, that it was of narrow application, and that its real import could not be gained until the case had been reviewed by a higher court. The Brown process was clearly defined as to certain successive steps in treating ores by cyanidation and concentration. * * * "First pulverizing the ore in the presence of cyanide solution; second, subjecting the ore to hydraulic classification by the introduction of cyanide solution at the bottom of an overflow tank to produce an ascending current; third, leaching the ore by the use of cyanide solution whereby the finer values of the ore are dissolved; fourth, removing the dissolved metallic values from the ore in any suitable manner; and finally, subjecting the residue of ore to concentration."

It appears that the process used by the Tonopah defendants involved crushing in cyanide solution, fol-

[1] "Operating Experiences with a Blast Furnace Gas Power Plant." Trans. Am. Soc. Mech. Engineers. "The Gas Engine in Modern Blast Furnace and Steel Plant." Ibid. Abstract of a paper read before the American Iron and Steel Institute—see *Iron Trade Review*, May 29, 1913.

[2] "Gas-driven Blowers at the Bethlehem Steel Co." Abstract of paper read before the Am. Iron and Steel Institute—see *Iron Trade Review*, June 19, 1913.

[3] L. C. Loewenstein, "Centrifugal Compressors," *General Electric Review*, March, 1912.

*See also the article on page 219 of our April issue.

lowed by concentration and subsequent cyanidation of the concentrates. Vincent sought to show that crushing in cyanide solution constituted essentially the cyanide treatment of ore by the defendant, and that the subsequent cyanidation of concentrates was an unimportant step, and that the process used was, therefore, essentially that of Brown. The Circuit Court of Appeals held differently, however: "After the defendant's concentration is finished the by-product goes forward to be subsequently treated by a protracted process of cyaniding. This is at variance with Brown's process in three respects; first, cyaniding follows concentrating (instead of preceding it); second, it is a system condemned by Brown and one he sought to avoid in that where 'concentration * * * is used preliminarily to the cyanide process it will be necessary to have a very extensive system of settling tanks in order to recover these suspended values and hold them in the mill so that they may be subjected to further treatment'; third, the defendant's process which physically withdraws from the operation of the process the products of concentration in advance of withdrawing those of cyaniding, makes the process one avoided by Brown, viz.: 'It is a well-known fact that the cyanide process recovers only the fine values, and in the treatment that I have devised these fine values are recovered by the cyanide process in the beginning, leaving only the coarser values, which are readily recoverable by concentrating, the latter being specially adapted for saving this class of values.' It is apparent, therefore, that the defendant's device, which the proofs show has been of great practical worth, owes its worth to the fact that it is built and operated in express disregard to the instructions of Brown's patent. Without passing on the question of the validity of that patent, it suffices to hold defendants do not infringe."

Other extracts from the decision, showing the reasoning of the court, are interesting: "It will be noted that no new principle of operation, either in cyaniding or concentrating themselves was disclosed in this patent. It was at most simply a more effective treatment and it will thus be seen that transposition of concentration from initial to final stage, and of cyaniding from final to initial stage, is the substantial disclosure of this device. * * * This two-staged process—first cyaniding, next concentrating—being the only disclosure of Brown and the claims embodying those two separate, individual, completed stages or steps, it follows that any process which makes concentration an intermediate and completed step, one that precedes final and effective cyaniding, is a process different from the one Brown disclosed and claimed. * * * The defendants, in common with Brown, it may be conceded, are using the cyanide solution in the earlier stage of their process, and to that extent we may say initially utilize the general chemical treatment incident to cyaniding, preparatory to concentrating. But beyond this the resemblance ceases, for by defendant's process concentration * * * is the initial and intermediate step in their process."

Company Reports

The seventh annual report of the **Goldfield Consolidated Mines Co.**, for the calendar year 1913, gives the following data on operation: The mines produced 349,465 tons of ore, of which 330,217 tons of an average gross value of $14.88 per ton was milled, and 19,248 tons of an average gross value of $27.39 per ton was shipped. The total gross value was $5,438,853. Deducting metallurgical losses, smelter discounts and the cost of a small tonnage purchased, an aggregate of $496,025, the value realized from the year's operations was $4,942,828. Expenses of mining, milling, transportation, construction, taxation and general expense amounted to $2,210,883, leaving a net realization of $2,731,945. Operating cost per ton was 54 cents lower than for the previous annual period. Two dividends were paid during the year, one for 30 cents per share and one for 40 cents, aggregating $2,491,404. At the close of the year the company's cash balance is $1,074,372, with bullion and miscellaneous products settlements outstanding of $161,217. The net realization from operation was 50.23 per cent of gross value of ore.

The report contains many detailed costs of operation, from which we take the following:

Segregaton of Milling Costs

Per Ton of Ore Milled

Department	Labor	Supplies	Power	Total	% Total
Crushing and conveying	$.017	$.008	$.005	$.033	2.08
Stamping	.032	.028	.065	.125	7.73
Chilian milling	.018	.033	.046	.097	6.07
Elevating and classifying	.012	.004	.006	.022	1.36
Tube milling	.014	.101	.107	.222	13.93
Concentration	.040	.007	.016	.063	4.00
Neutralizing	.007	.048	...	.063	3.46
Settling	.013	.049	...	.062	3.86
Dissolution	.021	.363	.034	.418	26.23
Filtering	.038	.025	.013	.076	4.78
Tailing expense	.001	...	...	.001	.09
Assaying	.003	.019	...	.022	1.39
Precipitation	.008	.055	.012	.075	4.68
Refining	.023	.041	...	.064	4.05
Water	.005	.066	...	.071	4.47
Surface and plant	.011	.005	...	.016	.97
Steam heating	.003	.007	...	.010	.60
Storehouse and office	.012	.003	...	.015	.94
Stable	.001	.001	...	.002	.12
Watchmen	.024	...	...	.024	1.52
Superintendence and foremen	.059	...	...	.059	3.72
Lighting	.002	.002	.014	.018	1.22
General expense	.003	.005	.001	.009	.55
Mill tools	.001	.001	...	.002	.07
Electrical department	.003	.003	...	.006	.33
Pumping battery water	.005	.002	.015	.022	1.34
Experimental	.005	.002	...	.007	.44
Totals	$.381	$.878	$.337	$1.596	100.00
Per cent of total cost of milling	23.90	54.99	21.11	100.00	
Per cent of combined cost of milling and concentrate treatment	19.35	44.59	17.12	81.06	

Segregation of Concentrate Treatment Costs

Per Ton of Concentrate Treated

Department	Labor	Supplies	Power	Total	% Total
Raw cyanidation	$.095	$.561	$.185	$.841	15.11
Filtering and conveying	.230	.045	.040	.315	5.66
Roasting	.223	.529	.102	.854	18.03
Acid treatment	.118	.403	.173	.694	14.65
Tube milling	.028	.018	.043	.089	1.87
Cyanidation of roasted product	.085	1.077	.138	1.300	27.42
Assaying	.016	.127	...	.143	2.57
Precipitation of copper	.024	.002	...	.026	.54
Precipitation	.014	.091	.019	.124	2.23
Refining	.038	.069	.001	.108	1.93
Disposal of tailing	.026	.017	.008	.051	1.07
General expense	.015	.011	...	.026	.47
Handling dump	.065	.010	.002	.077	1.63
Water	...	.323	...	.323	6.82
Totals per ton of concentrate	$.977	$3.283	$.711	$4.971	100.00
Totals per ton of ore	0.72	.248	.053	.373	
Per cent of total cost of concentrate treatment	19.65	66.04	14.31	100.00	
Per cent of combined cost of milling and concentrate treatment	3.66	12.59	2.69	18.94	

The report states that experiments are being continued looking toward means of successfully treating large quantities of low-grade ore that cannot now be mined and treated at a profit. No process has yet been devised to meet this need. In regard to tailings that have been impounded since the beginning of operations, careful experiments have shown that this material can be subjected to further treatment at a profit of a few cents per ton. Plans for equipment to handle the tailings are practically complete, and will be executed at the proper time. About five years' time will be required to treat the accumulation.

The constituent companies of **Phelps, Dodge & Co.** enjoyed uninterrupted operations during 1913, and produced more copper than in any previous year, according to the annual report for that period. Copper ores mined amounted to 1,978,892 tons, of which 1,122,372 tons was concentrated and the balance smelted direct. The quan-

tity of copper produced was 155,665,712 lb., containing 31,141 ounces gold and 1,870,162 ounces silver. Details of operation of constituent companies are as follows:

The reduction works department of the **Copper Queen Consolidated Mining Co.** treated 1,193,726 tons of copper-bearing material, producing 133,410,592 lb. copper, 1,870,162 ounces silver and 31,141 ounces gold. Experiments on dust losses from the large steel stack showed that copper loss had been reduced from a daily average of 14,310 lb. in 1909 to 2286 lb. in 1913, with practically the same number of furnaces and converters in operation. The two tests were taken in the same month and under similar weather conditions. In the blast-furnace department the flue dust produced was 3.92 per cent of the charge, as against 5.9 per cent in 1912 and 7.59 per cent in 1911. Furnace charge per day was 343.5 tons, of which 12.4 per cent was coke. Matte fall was 18.79 per cent. In the reverberatory department the McDougall roasting furnaces produced 56.5 tons of calcines per furnace per day, and flue dust to the extent of 5.2 per cent of the charge. Reverberatory furnaces smelted 289.6 tons per furnace per day. Oil consumption was 0.9 bbl. per ton of charge, of which 34.57 per cent was charged to steam and credited to reverberatories. Basic lined converters were used entirely throughout the year, treating 206,493 tons of matte and producing 67,256.6 tons of bullion from an average of 6.5 stands per day. In the power plant the cost per horse-power for the year was $54.844, and the average daily horse-power developed was 4595.8.

"During the year an experimental plant was completed, and experiments were conducted principally with the view of determining the best method of leaching low grade ores and the tailings from the cencentrators. A Wedge furnace, of the muffle type, was erected, which produced calcines containing a very high proportion of their copper soluble in water, and practically all of the remainder soluble in dilute acid, but with a high fuel consumption.

"The recovery of the dissolved copper was effected by electrolysis, using graphite anodes, and reducing the resistance and increasing the yield of sulphuric acid, by injecting sulphur dioxide into the electrolyte. The results were favorable, but several problems which presented themselves, as the experiments progressed, remain to be solved, as well as a reduction of the high fuel consumption, before definite conclusions can be reached."

The Detroit Copper Mining Co. of Arizona reports the treatment of 537,324 tons of copper-bearing material during 1913, with a yield of 22,255,130 lb. of copper bullion, at a rate of 41.42 lb. of refined copper per ton of ore. The average grade of all ore mined was 2.9 per cent copper, compared with 3.25 per cent for 1912. Concentrating ore averaged 2.78 per cent copper, compared with 3.08 per cent for 1912.

Concentrating operations are epitomized as follows:

Ore concentrated, 517,518 tons, assaying	2.785% cu.
Concentrates produced, 66,928 tons, assaying	15.834% cu.
Savings—Ore and concentrates	73.52%
Ore and tailings	75.18%
Concentrates and tailings	74.76%
Assay only	75.27%
Tailings assay	.79%
Tons ore milled per ton concentrates	7.73
Actual running time to total time	95.46%
Ore milled per 24 hours actual running time	1485.14 tons
Water used per ton ore milled	554.98 gal.

The smelting plant has been thoroughly overhauled and basic converting has replaced acid practice. At the power house a new boiler, steam turbine, Nordberg compressor and condensing plant were installed. A new furnace, flue, dust chamber and furnace building were erected.

Concentrator operations of the **Moctezuma Copper Co.** were as follows:

Ore milled	603,654 tons, dry weight, assaying 3.557% cu.
Concentrates produced	135,057.331 tons, assaying 13.376% cu.
Tailings produced	468,596.669 tons, assaying 0.67 % cu.
Saving (average, four methods of figuring)	85.0%
Ratio of concentration	4.469
Tons of ore milled per day, actual running time	1743.729
Fresh water used per ton of ore milled	1020.721 gal.

The cost of milling was slightly higher than in 1912, due to changes and repairs made in the mill.

The Burro Mountain Copper Co. reports an addition of about 50,000 tons of 2.35 per cent copper ore to known reserves. A favorable site for a concentrator of 1000 tons daily capacity has been chosen about 3 miles easterly from Tyrone. A central power plant, equipped with two 1000-hp Diesel engines, will be situated at Tyrone.

The fifteenth annual report of the **American Smelting & Refining Co.**, covering the calendar year 1913, shows that after charging off $1,525,518 for depreciation of property, and paying the usual dividends on preferred stock, the surplus income for the year was $3,736,541, of which $2,000,000 was paid to holders of common stock. The earnings from smelting and refining works and from mines are $3,570,532 less than during 1912. This decrease arises largely from the fact that ore mined from the company's properties, and awaiting transportation facilities, is valued only at cost of mining. A large credit of this character has been deferred awaiting normal conditions.

The company carries on its pension fund forty employees whose days of usefulness have passed. The income from the pension fund exceeded payments during the year by $10,395.

To promote fair treatment and cordial relationship between the company and its employees, the services of Hon. C. P. Neill, formerly Labor Commissioner of the United States Government, under the Roosevelt, Taft and Wilson Administrations, were secured in May, 1913, and the welfare work, hospital arrangements and employer's liability settlements of the company have been placed under the supervision of a committee, of which Mr. Neill is chairman.

The Iron and Steel Market

April has been a month of negative rather than positive developments in the iron and steel trade. The dullness which began late in February and reached an acute stage in March was almost universally expected to give way to more active conditions in April, a month marking the general inception of outdoor work and also a time by which the stocks accumulated by reason of the fairly heavy buying of January and early February should be exhausted.

The month, however, brought no improvement whatever in the iron and steel markets. In most quarters the feeling has been, on the contrary, that a great deal of ground has been lost. Close analysis indicates that there has been less of actual loss than there has been failure to attain what was expected. The current concepts of the state of trade are colored in pessimistic vein. This is illustrated by the fact that the rate of operation of the steel mills is frequently stated in current talk at less than the actual rate. There is excellent ground for an estimate that the steel industry as a whole has operated during April at fully 65 per cent of its full capacity, whereas statements have sometimes been made, and have gained considerable credence, that the industry has not been operating at more than 50 per cent. The reduction in mill activity has therefore not been large, for it is doubtful whether at any time in February a rate of more than about 75 per cent was attained.

The course of steel prices has been downward, though not radically so. A very low level was reached in De-

cember, forming the basis of the buying movement which began in that month and hardly lost its force until February was well advanced. Prices rose but slightly, and they have correspondingly declined but slightly, the level to-day being substantially the same as at the recent low point.

The outlook is extremely difficult to discern, and opinions now expressed by usually competent judges seem to be colored largely by individual temperament. Thus there are those who view the low rate of buying, a rate even below the lessened rate of producing and shipping, and conclude that the trade is booked for worse times, lower prices and lesser production than has yet been seen, while there are those others who reason that the buying has been abnormally low, below the actual rate of consumption, that everything bad has been "discounted' and that the market cannot grow worse. Hence they insist it must grow better.

For a time the steel industry embraced the view that a decision in the eastern freight rate case (now expected for about the middle of May) or possibly even an unfavorable decision, would be followed at once by a very considerable expansion, through buying not simply by the railroads but by other consumers as well, but lately this view has been in process of abandonment. The inception of spring has brought no improvement, and now hopes are beginning to center upon crop prospects, which are favorable and which are expected to become the subject of more detailed and precise information and prediction as the weeks pass. It is admitted at last that no improvement such as would operate the steel industry at capacity can possibly occur before September or October, while as to operations in the next two months the chances are about even for an increase or a decrease.

Pig Iron

Transactions in pig iron were very light in April, lighter even than in March. In many cases consumers reduced their requisitions against contracts, and such action coupled with extremely light buying has placed the furnaces in less comfortable position. Furnacemen have not, however, displayed any disposition to cut prices, their firmness in such circumstances being rather unusual. The American Pig Iron Association, formed January 8, may be partly responsible for the indisposition to cut prices, since while the association involves nothing by way of price agreement it has done much towards disseminating information as to production costs, which are alleged to be above selling prices, and has thus encouraged sellers to avoid cutting. Price changes in the month include advances of 50 cents at Cleveland and 25 cents at Buffalo and a decline of 25 cents in the southern market, so that the average level of prices is substantially unchanged, being, however, nearly 50 cents a ton above the low point late in January. Current prices are as follows: No. 2 foundry, f.o.b. Birmingham, $10.50; delivered Philadelphia, $15; f.o.b. furnace, Buffalo, $13.50; delivered Cleveland, $14.25; f.o.b. furnace, Chicago, $14.25; at valley furnaces (90 cents higher delivered Pittsburgh): Bessemer, $14; basic, $13; malleable, $13 to $13.25; No. 2 foundry, $13.25; gray forge, $12.75.

Steel

As forecasted in the report a month ago, the billet and sheet bar market has failed to advance $1 a ton as of April 1 through mills having been quoting $21 on billets and $22 on sheet bars for first quarter, and $1 advance over these figures for second quarter delivery. On the contrary, the highest that could be quoted as the market is $21 for billets and $22 for sheet bars, at maker's mill, Pittsburgh or Youngstown, while it is believed in many quarters that these figures could be shaded $1 a ton on any active inquiry. There has been no demand, however, and it is evident that mills covered quite generally for second quarter as well as first quarter when the market was at about $20 for billets and $21 for sheet bars, late in December and early in January. Forging billets are $25 to $26 and rods $26, Pittsburgh.

Finished Steel

Finished steel products have shown a declining tendency. Plates, shapes and bars have definitely dropped to 1.15c, and even relatively small lots can be secured at this level, which represented the extreme of the decline in December. Steel pipe was reduced one-half point, or about $1 a ton, through the new card issued April 20 by the National Tube Company, this change restoring the discounts in effect prior to the half-point advance of February 2. Line pipe was likewise reduced April 20. The sheet market has steadily softened.

Prices named below are f.o.b. Pittsburgh, unless otherwise stated:

Rails, standard sections, 1.25c. for Bessemer, 1.34c. for open-hearth, f.o.b. mill, except Colorado.

Plates, tank quality, 1.15c.

Shapes, 1.15c.

Steel bars, 1.15c., base.

Iron bars, 1.30c., Pittsburgh; 1.22½c., Philadelphia; 1.12½c., Chicago.

Wire nails, $1.60 per keg, base; plain wire, 1.40c., base.

Sheets, blue annealed, 10 gage, 1.40c.; black, 28 1.85c. to 1.90c.; galvanized, 28 gage, 2.85c. to 2.90c.; painted corrugated, 28 gage, 2.05c. to 2.10c.; galvanized corrugated, 28 gage, 2.90c. to 2.95c.

Merchant steel pipe, ¾ to 3 in., 80 per cent off list.

Steel boiler tubes, 3½ to 4½ in., 71 per cent off list.

Standard railroad spikes, 1.40c. to 1.45c., Pittsburgh; 1.50c., Chicago.

Structural rivets, 1.70c.; boiler rivets, 1.80c.

Cold rolled shafting, 64 to 65 per cent off list.

The Possibilities of St. Louis as a Field for Electrochemistry

Mr. C. F. Carrier, Jr., of the firm of Lawrence & Carrier, Inc., consulting chemical engineers of St. Louis and Memphis, lectured on the above subject on April 14 before the League of Electrical Interests in St. Louis in a most interesting manner.

He first sketched to what extent electrochemical industry already exists in St. Louis. "Electroplating is already old and will increase or diminish from other than electrochemical reasons. The laundries are making some bleaching liquor on a small scale for their own use by passing direct current through a solution of common salt. One plant for the production of oxygen and hydrogen gas is already in operation and a second one will be in use in the very near future. Sporadic attempts have been made to use the electric furnace for steel and brass, but it is only recently that a real steel furnace has been contemplated and will very soon be in operation.

"The location of an electrochemical enterprise is, of course, governed by the same general principles that apply in the location of any industry. The final test is will it pay? The most prominent factor is the power cost, but in many cases the less obtrusive factors have not been given due emphasis. Power is never the whole cost and in many cases industries classed as electrochemical, this factor will be less than 25 per cent of the manufacturing cost. It is but natural to contrast our situation with Niagara Falls and New York, the two great electrochemical centers of the country and see to what extent the various fac-

tors have determined the fixing of certain industries at these points.

"The first Niagara power was delivered August 26, 1895, and the power company was confronted with the problem of disposing of the largest single block of power that had ever been put on the market at one time. They soon found that the regular industries of the district would never be able to absorb so much power; therefore it became necessary to offer power at extremely low rates in order to stimulate the creation of new industries that could use large blocks of power. The effort was successful, and we now see the great industries that have made Niagara the great electrochemical center of the world. This power was offered at rates with which St. Louis can never hope to compete, but at the present time this power has been almost entirely absorbed, and the tendency of the rates has been steadily upward. There is still a small amount of power to be had right at Niagara Falls at rates somewhat better than are offered here in St. Louis, but the difference is rapidly disappearing and we find that at Buffalo the rates are really higher, as shown by contract forms from Buffalo and St. Louis in my possession and the terms of contract are favorable to St. Louis, as the Buffalo contract stipulates such a high rate during the peak hours that the average price per kilowatt for 24-hour service would be materially increased.

"For large blocks of power with a high load factor a very good rate can be obtained in St. Louis. An electrochemical plant would operate 360 days per year, and under proper management should be able to maintain a load factor of 85 per cent. On a basis of 50 kw the net cost per kilowatt hour in St. Louis for prime power would be 7¼ mills. This figure only applies to large blocks of power with a high load factor such as would be the condition in an electrochemical plant. For larger loads an even better net cost is obtainable. For other manufacturing purposes the power rates at practically all points in the country are on a competitive basis with steam-driven plants, and owing to its cheap supply of fuel St. Louis has a great advantage over Buffalo.

"The figures discussed above are based on power purchaser from central stations. It will be interesting to know what can be done with the isolated plant. Central station managers have been slow to realize what extremely economical results have been obtained in the power plants of some of the electrochemical plants, especially in the copper refining industry. Near New York City, with coal costing more than 100 per cent higher than at St. Louis, plants of over 10,000 kw are delivering power at the switchboard, and this is refined power direct current, at 6 mills per kilowatt-hour. This figure can nearly be duplicated at East St. Louis with a 1000-kw plant operating 360 days per year with an 85 per cent load factor and a 10,000-kw plant would give a figure of 5 mills. Such a plant is not a chimera, for there are single electrochemical industries taking from 10,000-40,000 kw.

"The central station manager has also been slow to realize the possibilities of adjusting a heavy off-peak load to balance the load factor of the station. An electrochemical plant having a normal demand of 1000 kw could be arranged to take 25-35 per cent overload during the off-peak hours. Practically every station has a large amount of idle apparatus during at least 16 hours per day, and usually longer. This power, taken only above the normal demand and only during off-peak hours, could be sold profitably at a very low price, and the effect would be to raise the load factor of the power plant and to diminish the net cost per kilowatt-hour to any consumer who could meet the load conditions specified, say a load factor of over 80 per cent.

"Those industries in which the cost of power is an overwhelmning factor in the cost of production must of necessity go to the cheap power. Nitric acid is made from the atmosphere in Norway by high-tension electric arcs, and pig iron is made in California in an electric furnace, but even Niagara cannot compete with either. Calcium carbide, carborundum and graphite are for the time at least beyond the reach of St. Louis competition, and we shall probably continue to see aluminum oxid made in East St. Louis shipped to Niagara and Massena Falls and the finished metal shipped back to St. Louis, but this does not prove that there is no hope for St. Louis in the electrochemical field.

"When the ratio of power cost to selling price begins to diminish, as is the case with many of the other electrochemical products, the increasing importance of other factors will soon counterbalance even a substantial power cost difference, should such exist. A few examples will show this very clearly; 70 per cent of the world's production of copper is refined in the New York manufacturing district with steam power that in times past at least has been 50 per cent higher than at Niagara. Electric steel is being made in all parts of the world with energy from all types of prime movers and at prices ranging from $10-$150 per horsepower per year. Most of the electrolytic caustic soda and bleach made in Europe is with steam-driven power plants, and there are two such plants within a few miles of New York City operating profitably and using power that costs over 100 per cent higher than the St. Louis central station rate for the same power conditions.

"Assuming caustic soda to be manufactured at St. Louis, about 25-35 per cent of the manufacturing cost will be power. This cost would be approximately $20 per ton of finished caustic, charging all the power to the one product. At the rates which the caustic plants were able to obtain at Niagara when they started, the advantage would be about $9 per ton against St. Louis. This puts the situation in the most unfavorable light possible, but even so, competition is well within the bounds of commercial possibility. Cheaper fuel for evaporation of the product amounts to $1.50, the saving by distributing locally in tank cars instead of reducing to a solid saves $3 in containers, labor and fuel, lower freight to natural market might amount to $3-$5 per ton, hence there is a large natural market within the bounds of which a St. Louis plant would have a substantial advantage over Niagara and Michigan points.

"One of the most alluring fields for St. Louis is in the melting of steel, copper, brass and other alloys."

Among other electrochemical possibilities Mr. Carrier mentioned that St. Louis alone purchases upward of $50,000 worth of barium peroxide per year from England, yet St. Louis has barium sulphate rock almost at its door. This can be reduced to over 90 per cent soluble condition in an electric furnace, while only 60 per cent becomes soluble in a fire furnace. The author concluded with the expression of his firm belief in the electrochemical possibilities of St. Louis.

The production of aluminium ore in the United States in 1913 amounted to 210,241 long tons, valued at $997,698. This is an increase of 31.5 per cent in quantity and 29.8 per cent in value as compared with 1912. Alabama, Arkansas, Georgia and Tennessee were the producing states.

The Development of Copper Leaching and Electrolytic Precipitation at Chuquicamata, Chile[1]

BY E. A. CAPPELEN SMITH

The Chuquicamata copper mine is located at Chuquicamata, a station on a branch of the Antofagasta and Bolivia Railroad, in the Province of Antofagasta, Chile, between 22 and 23 degrees South latitude. Chuquicamata is 165 miles by railroad from Antofagasta, and 82 miles in a straight line from the coast and lies at an altitude of 9500 ft. above sea level.

The deposit has long been known as the atacamite deposit of Chile, and for many years past has been mined by the natives. As evidence of their operations we find in the old workings many stone utensils, hammers, etc.—and mummies.

The deposit is a brochantite mineral contained in the cleavages of the granodiorite, mixed in part with chalcanthite and to some extent with atacamite, and with a deposit of salt. A small amount of caliche containing nitrates is also present in the upper layers of the ore-body.

The so-called Llampera ore body extends for a distance of approximately 8,000 ft. with an average width of about 500 ft. Throughout the whole length of the deposit numerous tunnels have been run and a very large quantity of ore has been left on the dumps from these tunnels. From the tunnels raises have been made almost to the surface, leaving in places a shell over the workings 8 to 12 in. thick. A few shafts have also been sunk in the ore deposits, the deepest one to a depth of 110 meters.

Acquisition and Development of the Property

The property was acquired by Mr. Albert C. Burrage of Boston, who, in connection with the firm of Messrs. M. Guggenheim's Sons, formed the Chile Exploration Company, which company now owns the property.

The property has been explored by churn-hole drilling. The drilling has developed an ore-body in excess of 200,000,000 tons. Most of the drill holes, however, were stopped while the bottom of the hole was still in ore.

The general direction of the ore body is north and south. Lately a number of drill holes have been sunk at a considerable distance west of the Llampera, and after going through from 300 to 400 ft. of capping, chalcocite and chalcopyrite have been encountered, giving indications of a very materially increased tonnage over that reported up to date.

In the Llampera zone, of the 200,000,000 tons of ore so far developed, approximately two-thirds is brochantite and one-third sulphides. No change in the formation has been shown, even in the deepest drill holes, the ore still appearing to be in the cleavages of the granite. The lower drill holes show primary ore. From the amount of ore developed and indicated, it appears that the Chuquicamata mine is probably the largest copper deposit known to-day.

It was generally assumed that this large and well-known deposit of ore was atacamite, and as such could not be treated at a profit by any of the established methods; first, on account of the highly siliceous nature of the ore and the absence of sulphides and water, and, secondly, on account of the volatilization in smelting of the copper chloride.

It was demonstrated that the mineral was not atacamite (oxy-chloride) but brochantite (oxy-sulphate) and that mixed with the brochantite in the upper parts of the ore-body was a deposit of salt. The brochantite, being an oxy-sulphate of copper, is insoluble in water but very readily soluble in dilute sulphuric acid. It was, therefore, evident that the way to treat the brochantite ore-body would be by wet methods.

Preliminary Experiments

About 600 tons of the oxidized ore, representing, as near as we can judge, a fair average of the oxidized ore-body, have been shipped to New York for experimentation on a small scale.

At first tests were run on a very small scale and gradually, as promising results were obtained, on a somewhat larger scale, treating about 2 tons of ore per day. The average content of the ore thus treated was somewhat in excess of 2 per cent in copper.

The main problems which presented themselves for solution were:

1. The solubility of the copper minerals in sulphuric acid.
2. The amount of chemicals required as a dissolving agent.
3. The amount of impurities which would enter the solutions, and
4. The precipitation of the copper from the solutions obtained.

The principal developments in the solving of these problems may be briefly summarized as follows:

1. **Solubility of the Mineral**—Experiments conducted on a small scale disclosed the fact that the copper-bearing mineral was very readily soluble in a cold dilute sulphuric acid solution and that only comparatively coarse crushing would be required.

2. **Chemicals Required**—After prolonged experimentation, it was found that the ore yielded enough sulphuric acid, from the decomposition of the copper sulphate present in the brochantite, to more than make up the losses in sulphuric acid in the operation. The losses of acid occur mainly in two stages: first, the loss due to dissolving other components besides copper from the ore; and, second, due to wasting of solutions through discarding of the residues.

3. **Impurities Entering the Solutions**—Experimentation extending over a long period of time has shown that no deleterious amount of impurities will accumulate in the solution, other than the chlorine derived from the salt deposit mixed with the mineral in the upper parts of the ore body.

4. **Precipitation of the Copper**—The experiments conducted in our experimental plant have shown conclusively that electrolytic copper of the highest grade can be produced from the sulphuric acid solutions obtained.

Experimental Leaching

After completing a number of leaching tests on a laboratory scale, and after running a number of tests each with 100 kilos of material, experimentation was inaugurated on a larger scale and a plant was built of sufficient size to treat two tons of ore per day.

In this plant there have been treated 131 charges of ore and the plant has been run entirely as a self-contained unit—leaching the ore, washing it, purifying and electrolyzing the solutions obtained, and leaching the following lots of ore with the electrolyzed solution from previous charges.

In this plant were treated ores representing the general character of the oxidized ore body at Chuquicamata; some high in copper, others low in copper; some high in impurities, others low in impurities, and enough runs were made to prove the method on both

[1] A lecture delivered at the 25th General Meeting of the American Electrochemical Society, Columbia University, New York City, April 18, 1914.

high and low-grade ores, and on ores containing large amounts of salt as well as smaller amounts of salt, this being the principal impurity in the ore-body. The salt deposit, however, is confined to the upper 50 ft. of the ore-body and principally to the first 25 ft.

In order to make sure that the method should be tested under the most adverse conditions, the same solution was used over and over again for the treatment of the before-mentioned 131 charges of ore, only setting aside enough solution to allow for the excess acid. A complete analysis of this solution was then made and showed the following contents:

	Grammes per litre
Cu	50.44
Fe	3.71
Mn	0.07
P	0.06
As	nil
Sb	nil
CaO	0.80
MgO	3.32
Al_2O_3	1.61
Na_2O	21.60
K_2O	5.00
SO_3	122.75
Cl	11.52
Free acid (as H_2SO_4)	28.00
Total solids on ignition	189.40
Nitric acid	4.00

The results obtained when using the solution which had previously treated 131 charges of ore were just as good as the results with the solution made from sulphuric acid and water. In other words, the accumulation of impurities has been proven to have absolutely no effect whatever on the results of the leachings obtained. The average extraction obtained in this 2-ton plant was 90.99 per cent.

Following the experiments in the 2-ton plant, a leaching tank was built of concrete, lined with mastic asphalt, having a cross section of 4 ft. x 6 ft. and 15 ft. deep, holding 15 tons of ore, this allowing the use of the full height of ore column since adopted for the plant now building at Chuquicamata. The question to be decided was whether it was feasible to leach the ore in tanks of this depth. Extensive experimenting gave results confirming those obtained in the smaller tanks.

A wooden filter-bottom with cocoa-matting on top has been employed in the 2-ton tanks and in the 15-ton tank, although a great number of leachings were made without any filter-bottom, simply placing a piece of cocoa-matting over the out-flow pipe.

All leachings were made without applying any extraneous heat.

The washing of the ore was by the so-called "piston" method, with a final water-wash, and the tailings, or residues, discharged contained an average of about 12 per cent moisture, and about 0.04 per cent water-soluble copper.

Extractions Obtained

The leaching results obtained up to date are as follows:

The average extraction while treating the ore in lots of 100 kilos each was 90.62 per cent

The average of 131 charges treated in the 2-ton plant shows an extraction of 90.99 per cent

The average extraction obtained in the 15-ton tank, while treating 25 charges leached up to date, has been 90.96 per cent

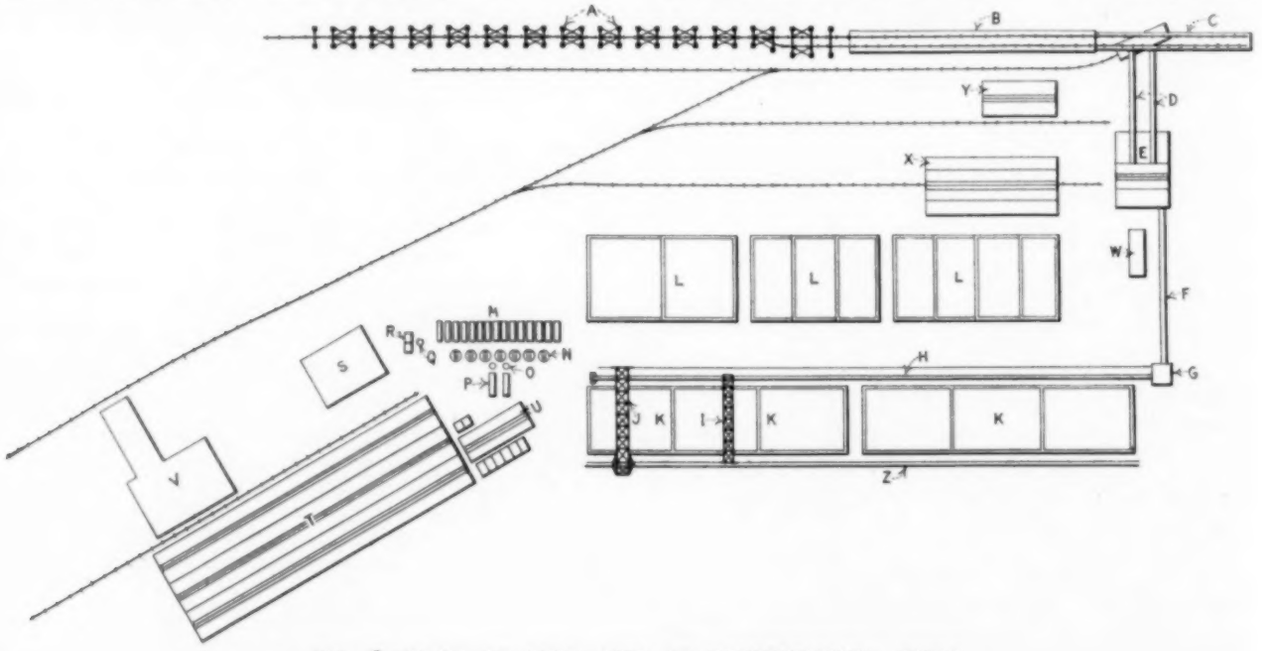

FIG. 1—PLAN OF MILL SITE AT CHUQUICAMATA, CHILE

Key to Drawings

A—Approach trestle.
B—Ore bin.
C—Gyratory breaker house.
D—36-in. belt conveyors.
E—Crusher house.
F—36-in. belt conveyor.
G—Sampling bin.
H—36-in. belt conveyor.
I—Filling bridge.
J—Reclaiming bridge.
K—Leaching vats (6).
L—Solution sumps (9).
M—Dechlorinating drums (21).
N—Settling tanks (7).
O—Montejus (2).
P—Filter presses (2).
Q—Reservoir from settling tanks.
R—Pumping plant to tank-house head tank.
S—Tank-house head tank.
T—Electrolytic tank-house.
U—Main pumping plant.
V—Substation.
W—Transformer station.
X—Machine shop.
Y—Warehouse.
Z—Tailings conveyor, 36 in.

These results being based on the weight and sampling of the ore as charged into the tanks and the weight and sampling of the residue discharged from the tanks.

By combining all of these leachings and taking the copper contents based on the weight and sample of the ore treated, as against the copper produced in the

electrolytic tanks in the form of cathode copper, together with the copper held in solution as copper sulphate, the extraction was 89.6 per cent. The small discrepancy is accounted for by solutions, of which no account has been taken, which have been removed for special tests, as well as spills which will necessarily occur in operating a small scale plant.

Amount of Chemicals Required

After having supplied the amount of sulphuric acid required to start the operations, it was found that not only was no further acid required, but that excess acid was produced from the sulphuric acid contained in the ore itself, to such an extent that an actual gain is shown of approximately 9 pounds of acid (H_2SO_4) per ton of ore treated. In other words, it will be necessary to discard an amount of solution equivalent to this gain in acid in order to prevent the acid from accumulating in the process. This gain in acid was made while treating an ore averaging a great deal higher in salt than even the average of the upper layers of the ore body at Chuquicamata will show. As the greatest loss of acid is in forming sodium sulphate, I believe that a still larger gain in acid will be shown when treating the average ore body.

Impurities in Solution

Of the impurities accumulating in the solution, the principal elements, outside of the chlorine present, are nitric acid, alumina, iron and alkali salts. After more than a year's work with the same solution, discarding only enough solution to take care of the excess acid, we find the following impurities present:

	Grammes per litre
Fe	3.71
Mn	0.07
As	nil
Sb	nil
CaO	0.80
MgO	3.32
Al_2O_3	1.61
Na_2O	21.60
K_2O	5.00
Nitric acid	4.00

This amount of impurities is insignificant so far as effect upon the leaching and electrolysis is concerned.

The main impurity in our solution is the chlorine obtained from the salt in the upper part of the orebody. It was at first thought desirable to electrolyze direct the solution containing the chlorine and it was found perfectly feasible to do this in covered electrolytic tanks, maintaining a slight vacuum so that the chlorine gas was all drawn off through fans. However, it was also proven that only a part of the chlorine was eliminated in this manner and that an appreciable quantity was deposited with the cathode copper in the form, probably, of cuprous chloride.

Elimination of Chlorine

Further experimentation proved that it was feasible to eliminate the chlorine from the solution by treatment with shot copper, the reaction resulting in the production of insoluble cuprous chloride. This precipitate settles readily.

Various methods of precipitating cuprous chloride were tried and finally shot copper, placed in a revolving drum, was adopted as the most satisfactory method. The cuprous chloride forming on metallic copper sticks tight to the copper shot, and it was found necessary to present continuously clean surfaces of copper in order to maintain an effective precipitation. After trying out several methods it was decided that the best apparatus for this purpose would be revolving drums similar to tube mills, through which the solution would be passed in contact with the shot copper contained in the drums, as in this way the copper, rubbing against itself, continuously presents a clean surface.

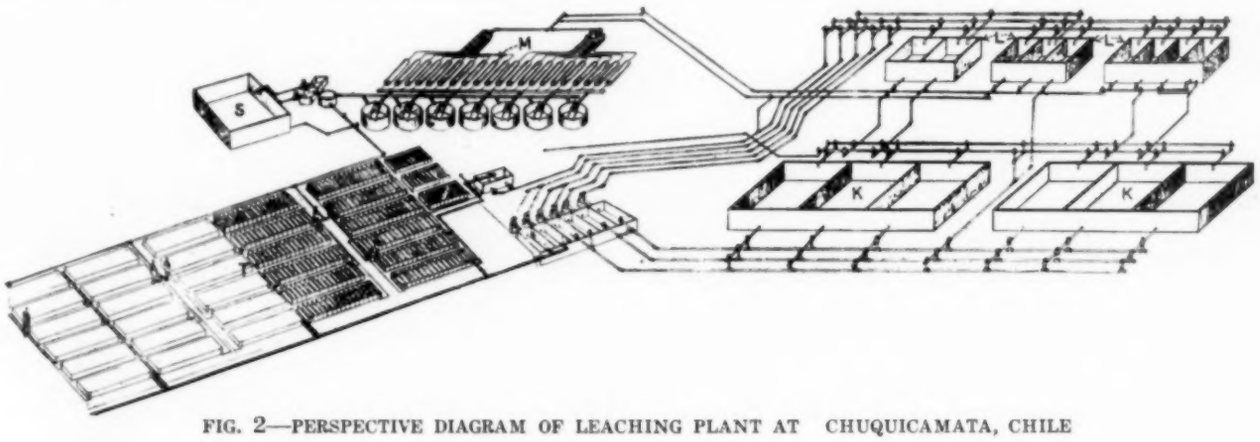

FIG. 2—PERSPECTIVE DIAGRAM OF LEACHING PLANT AT CHUQUICAMATA, CHILE

Precipitation with cuprous oxide gas also tried and worked very well except that the efficiency of the copper in this form as a precipitating agent, was found to be very much lower than that of metallic copper, even allowing for the theoretical difference.

The cuprous chloride produced may be treated in several different ways. It is our intention to filter-press the settled cuprous chloride, mix the filter press cakes with limestone and coke, and smelt the product thus obtained, producing metallic copper and calcium chloride as a slag. A number of experiments have been conducted with this mixture to establish the reaction, and it has been found that a very liquid slag of calcium chloride is produced containing a very small amount of copper, and that in this manner it is perfectly feasible to smelt the cuprous chloride without any loss by volatilization.

Some small scale experiments have also been made looking to the electrolytic treatment of the cuprous chloride and later on it may be possible that this latter method will be adopted, if found more profitable, in preference to the smelting method.

Precipitation of the Copper

The solution, freed from its chlorine content, is now electrolyzed, using insoluble anodes and ordinary copper cathode starting sheets. After a vast amount of experimenting, we have decided to employ an insolu-

ble anode made of magnetite. Various other anodes have been tried with more or less success, but after having investigated all the possibilities we have decided upon the magnetite anodes.

Experiments with these anodes have extended over about a year and a half, and we have found no material amount of chemical wear on the anodes. The magnetite anodes which we have adopted are manufactured by a secret process by the Chemische Fabrik Griesheim Elektron, of Frankfort, Germany. The nature of the material naturally gives a brittle anode. However, as it will not be necessary to handle the anodes after they are installed in the tanks, this is not a very decided drawback.

At first a number of difficulties were encountered in our efforts to secure an even current distribution and proper suspension of the anodes, but all of these obstacles have been overcome and we believe that a very serviceable anode has been developed.

The anodes themselves are hollow castings with a wall thickness of approximately ¼ in., and have a thin electroplated copper deposit on the inside.

As I am not myself familiar with the methods employed in the manufacture of these anodes, I am unable to give any further information on this point. I can only state that after months of continuous operation we have found the anodes entirely satisfactory for our purpose.

The copper cathodes produced from the electrolysis are of the usual quality of cathode copper—in fact, a little better—as in our particular case no arsenic or antimony, usually the most deleterious impurities in cathode copper, is present in the solution.

The solution will enter the head tank of the electrolytic system containing approximately 5 per cent copper and 2½ per cent to 3 per cent free acid, and will leave the last tank of the cascade containing about 1.5 per cent copper and 8 per cent to 9 per cent free acid. Within these limits it is always possible to produce a good hard cathode, equal to or better than the usual standard.

The electrolytic tanks used during our experiments are made of concrete, lined with mastic asphalt.

Design of Plant now Building at Chuquicamata

On account of the very large ore body already developed at Chuquicamata the first unit of the plant now building has been designed to treat about 10,000 tons of ore per day. The electrolytic refinery will have a capacity of about 335,000 pounds of copper per day.

The ore will be mined by steam shovels, practically no stripping being necessary. The ore will be transported to the mill, distant about 2½ miles from the mine, in standard American gauge railroad cars of 60 tons capacity each.

Arriving at the plant, the ore will first pass through gyratory crushers, thence through 48-in. Symons disc crushers, and finally through Garfield rolls until a product is obtained of about ¼ in. mesh. The ore will be carried on conveying belts from the crushing plant, after sampling, to the leaching vats. Each of the leaching vats has the following dimensions, 110 ft. wide, 160 ft. long and 16 ft. high. The leaching vats, six in number, will be placed end to end.

The belt delivering the ore from the crushing plant will be discharged into the leaching vats with the aid of an electric traveling bridge, spanning and traveling the entire length of the leaching tanks. The leached and washed residue will be removed from the leaching tanks by a 15-ton grab bucket traveling on an unloading bridge and, after sampling, will be delivered onto a conveying belt for disposal to the tailings dump.

The tanks are being built of heavily reinforced concrete, and will be lined with mastic asphalt 1½ in. thick. This tank lining has been developed by the Vulcanite Paving Company of Philadelphia, and consists of a specially refined Trinidad asphalt mixture, to which is added crushed quartz or granite.

In our experimental plant, where this lining has been in use for considerably more than a year, both in the leaching and electrolytic tanks, absolutely no difficulty has developed—not even a single leak. We have tested the material at a temperature of 50 deg. C. without finding any signs of softening, and as this is far beyond the range at which we intend to operate tests at higher temperatures have not been made, although the temperature limit, so far as softening is concerned, will probably lie somewhere between 50 deg. and 70 deg. C.

Tests have also been made to try the strength of this material from a physical standpoint, and in one case a 250-pound cathode was elevated about 5 ft. above the bottom of the tank and then dropped in such a way that one of the sharp corners of the cathode hit the bottom of the asphalt-lined tank. In this case a piece of the lining about ⅛ in. thick and 2 ft. in diameter was broken away, and as far as we could see the tank lining was just as good as ever.

The material has been tested in strong and weak acid solutions and found to be absolutely unattacked.

From the bottom of the leaching tanks the solution will be removed through eight 6-in. openings equally distributed over the tanks. A filter-bottom, consisting of two layers of 2-in. planks with a layer of cocoa-matting between, will be employed. This filter-bottom will be raised 4 in. above the bottom of the tank.

For the main solution circuits, 9-in. and 16-in. lead-lined iron pipe will be used. Open-boot horizontal centrifugal pumps, made of type-metal, will be used for pumping the solutions. The pumps will have a capacity of 550 cu. ft. per minute, elevating to a height of 60 ft.

In the leaching plant the cycle of operation will require approximately six days, of which one day will be occupied in filling the tank, two days in leaching, two days in washing and draining and one day in discharging.

The solutions will be conducted to the leaching tanks by gravity from nine solution-storage tanks placed above the leaching tanks. The dimensions of these solution-storage tanks are as follows:

Two tanks	12 ft. x 130 ft. x 150 ft.
Seven tanks	12 ft. x 70 ft. x 150 ft.

From the strong-solution tank the solution will flow by gravity through the dechlorinating plant, consisting of twenty-one 30-ft. long by 4-ft. inside diameter revolving steel drums lined with earthenware. These drums will be half full of shot copper. From these drums the solution, containing the cuprous chloride in suspension, will flow to seven Dorr thickeners made of concrete and lined with mastic asphalt. The clear solution overflowing will travel by gravity to the electrolytic refinery, while the thickened cuprous chloride, together with approximately 1 per cent. of the original solution, will go to filter presses.

The electrolytic refinery will consist of 510 electrolytic tanks of the following dimensions: 19 ft. long, 3 ft. 6 in. wide, 4 ft. 10 in. deep. They will be made of concrete, lined with mastic asphalt, and will be set through the floor, having inspection aisles underneath and a concrete working platform between the rows of tanks. The tank-house will be of concrete and steel construction.

Of the 510 tanks, 30 will be used for making cathode starting sheets, and the balance, 480 tanks, will be

used for electrolytic deposition of the copper from solutions. The tanks will be arranged in five electrical circuits, with 96 tanks to a circuit, and will be divided into 30 solution circuits, the solution in each circuit flowing through 16 tanks placed in cascade.

The anodes, made of magnetite, will be 5 in. wide, 2 in. thick and 4 ft. long, with five to a bar. The cathodes will be 3 ft. wide by 4 ft. deep.

The spent electrolyte, containing about 1.5 per cent copper, will be pumped back to the storage tanks to be used for leaching subsequent charges of ore.

The cuprous chloride from the dechlorinating plant will be smelted and cast into shot copper for use in the dechlorinating drums.

The power plant will consist of a primary power station at the coast, using oil-fired Babcock & Wilcox boilers driving four steam turbines, connected to four 10,000 kw. alternating current generators. The current will be transmitted 85 miles at 100,000 volts to a sub-station located at the mill-site. The sub-station for the electrolytic refinery will consist of seven motor-generator sets, each of 2,500 kw. capacity.

Conclusion

It will be readily understood that a vast amount of experimental work has been conducted in order to arrive at a satisfactory solution of the problems before us in connection with the ores from Chuquicamata, and a great many negative results have been obtained as well as positive results. From fifteen to twenty young engineers have been continuously employed for more than a year on this experimental work, the experimentation going on steadily in three 8-hour shifts.

It has been our endeavor in conducting the experiments to operate each part of the apparatus on what we might term a cross-section scale of the plant to be erected at Chuquicamata. We have thus used a leaching tank with the full depth of ore column, the important point in leaching, and we have used the same material for filter bottoms as will be used in the large plant. We have had full size solution valves installed. In connection with the dechlorinating plant we built a full cross section drum. In the electrolytic tanks we have been operating with full size cathodes and anodes. In short the idea has been to approach in our experiments, as far as possible, operating conditions similar to those which we will have in the large plant.

I wish to take this opportunity to state that great credit for the results obtained should be given to the loyal and enthusiastic staff employed, and I will particularly mention in this connection Mr. C. A. Rose in charge of the experimental work at the plant, and his able assistants, Mr. Leonard M. Green, who, under Mr. Rose, has had charge of the leaching part of the experiments and who has developed the details of the leaching and washing system now adopted, and Mr. M. R. Thompson, who has had charge of the electrolytic part of the experiments.

The Tulsa Spelter Company, Sand Springs, Okla., had under construction in 1913 a 4000-retort plant. It is expected that operations will commence this month with 1600 retorts.

Columbia University has issued a pamphlet giving information regarding the new advanced courses in engineering and technical studies. From and after July 1, 1915, the Schools of Mines, Engineering, and Chemistry will become advanced or graduate schools, and candidates for admission will be required to show evidence of preliminary training equivalent to three years study in a college of scientific school of high rank.

The Cost and the Advantages of Using Electrically Melted Ferromanganese

Electric steel furnaces of various types have found a new field of application in recent years, as they are being widely used in Europe to keep a molten supply of ferromanganese on hand at the converter plant. The use of molten ferromanganese instead of solid ferromanganese not only results in a saving of alloy, but makes the deoxidation more efficient and the steel better; and the cost of melting the ferromanganese electrically is more than counterbalanced by these advantages.

This method has been widely introduced during the last few years in Europe. The first plant to take up this practice in this country has been the Illinois Steel Company, which at its converter plant at Joliet, Ill., employs a 4-ton Heroult furnace to keep on hand a supply of molten ferromanganese from which 150 lb. are taken every seven minutes. It is the experience of this company that besides the saving in alloy there is a clear advantage in quality, the soft steel produced being decidedly better for wire purposes.

In Europe various types of electric furnaces have been employed for the same purpose, and the induction furnace has found particular favor in several plants. As very few exact figures have been published in the past on this subject the following results obtained in three European plants employing induction furnaces for melting ferromanganese should be of timely interest:

The three plants in question use for this purpose a 3-ton, 350-kw furnace, a 4-ton, 500-kw furnace, and a 4-ton 500-kw furnace respectively, all being of the three-phase, 50-period, three-ring Roechling-Rodenhauser type, the design of which is very well known to our readers.

In the plant using the 3-ton, 350-kw ferromanganese-melting furnace, some thirty to fifty tappings, ranging each from 90 to 120 kg (198 to 264 lb.), are made every twenty-four hours, depending upon the demands of the steel plant. For the first five weeks the average energy consumption, excluding the energy required for burning in the lining, was 721 kw-hours per ton for an output of 220 tons of ferromanganese.

To maintain the furnace hot during long intermissions 200 to 250 kw are required.

As a result of using molten ferromanganese, an average saving of 30 to 40 per cent of weight of ferromanganese required is recorded. With cold ferromanganese from 7 to 8 kg are used per ton of steel and during a year some 2100 tons of cold ferromanganese are required. With molten ferromanganese this amount is reduced to less than 1400 tons, representing a saving of more than 700 tons, which at $55 per ton represents a saving of $38,500 per year.

In one of the plants with a 4-ton, 500-kw furnace ferromanganese has been melted at the rate of 10 tons per twenty-four hours with an energy consumption of 750 kw-hours per ton. The furnace, however, is capable of melting a considerably higher tonnage of ferromanganese per day and when the demand of the steel works increases it may be expected that the specific energy consumption will be reduced.

At the same time the amount of ferromanganese used per ton of steel has been reduced at this plant from 7.5 or 8 kg (for cold metal) to 4 kg (for molten metal), which is a saving of from 45 to 50 per cent.

If the results of these two furnaces are used on which to base an estimate of the power requirement and savings to be expected in new installations, it seems safe to figure on a saving of 30 per cent in weight of

ferromanganese and a power consumption of 675 kw-hours per metric ton of ferromanganese for a 3-ton furnace in regular operation. For burning in the lining and heating up a 3-ton furnace about 3500 kw-hours are required and a life of 12 weeks, or 84 days of twenty-four hours, may be expected for the lining. From these data a figure for an additional small power consumption may be deduced. As stated, all these figures refer to induction furnaces. It would be interesting to get for comparison data from arc-furnace installations.

The use of molten ferromanganese has, however, additional advantages which cannot be stated as easily in figures. Owing to the rapidity with which molten ferromanganese becomes distributed through a steel charge much time is saved owing to the fact that the steel may be teemed at once. Further low-grade ferromanganese, containing large percentages of fines, may be easily melted in an electric induction furnace.

That the quality of the steel is improved by the use of molten ferromanganese will be understood from the following considerations:

The deoxidizing effect is much stronger and more rapid than with solid ferromanganese, as the latter must first be dissolved and exerts a certain cooling effect.

As the ferromanganese is added to the steel while teeming, it does not come into contact with the slag, and rephosphorization by reduction of the phosphates in the slag is entirely excluded.

Frequent analyses in the three induction furnace installations in question have proved that the composition of the steel remains constant from the first to the last ingot for any one charge.

On account of the uniformity of the composition of each ingot due to the better distribution of manganese and also to the more complete deoxidation the steel "rolls" extremely well. It has been proven that a section which, when cold ferromanganese was used, could not be satisfactorily rolled with steel containing less than 0.4 per cent Mn, can, when molten ferromanganese is used, be rolled easily from steel containing only 0.29 per cent Mn.

The amount of ferromanganese per ton of steel can be considerably reduced on account of the certainty that the total amount of ferromanganese added is utilized and nothing is retained in the slag or remains undissolved in the steel.

The contents of the ladle can be poured at once whereas much time is saved and, moreover, the charge need not be so hot from start so as to be able to heat the ferromanganese to melting temperature. The liquid steel remains completely quiet, does not boil, and can be poured very satisfactorily.

The lining is put into ferromanganese induction furnaces in about the same way as in steel furnaces; that is, a mixture of magnesite, or dolomite, with tar is rammed in hot. But because the temperature required is not so high as for steel and also because ferromanganese is usually in particularly convenient form for melting in an induction furnace, the life of the lining is much prolonged. From the results so far obtained it is thought possible when working continuously to average between four and five renewals per year, or even better.

No slag is required. The molten metal is effectively protected from oxidation by a layer of carbon in the form of petroleum coke. The metal being saturated with carbon, no alteration in composition occurs. The fact that such a covering is used proves that the atmosphere in the furnace is non-oxidizing.

While, as stated before, the Roechling-Rodenhauser type of combination induction furnace is used in the three installations here discussed, the Siemens & Halske Company, which made these installations, has developed more recently an improved type of induction furnace which combines the good points of the Kjellin, Roechling-Rodenhauser and Frick types and with which it has been possible to reduce the specific energy consumption still further.

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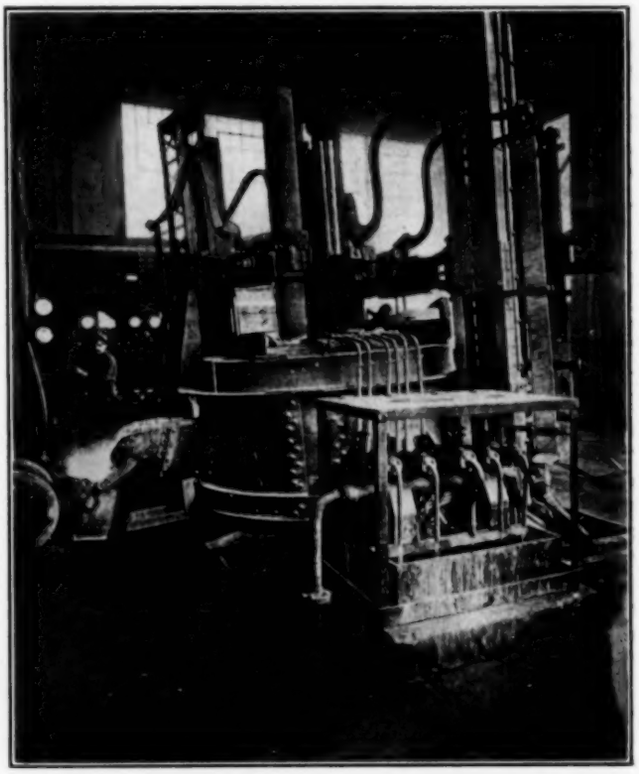
While the data given above from European practice refer to plants using induction furnaces for melting ferromanganese, other types of electric furnaces are also used for this purpose in Europe. The adjoining



ELECTRIC FURNACE FOR MELTING FERROMANGANESE AT KRUPP PLANT

illustrations show a five-ton Girod furnace recently installed by the Friedrich Krupp A. G., Friedrich-Alfred Hütte, Rheinhausen-Friemersheim, Germany, for the melting of ferromanganese.

Salt Lake City Meeting of American Institute of Mining Engineers

The one hundred and eighth meeting of the Institute will be held at Salt Lake City, Utah, August 10 to 14, 1914, inclusive. Local committees have been active in preparing for the entertainment and convenience of visiting members and an excellent technical program has been provided. Twenty-five papers have already been accepted for this meeting and others are expected. Authors are urged to have all papers in the hands of the secretary by May 15 if possible, and not later than May 31. Papers will be printed and distributed in advance to those members desiring to prepare discussions.

The social features of the Salt Lake City meeting will include visits to the neighboring mines and metallurgical works at Bingham Canyon, Garfield, Lark, Murray, Midvale, Park City and Tintic.

Adequate provision is being made for the comfort and entertainment of ladies, and a special committee has been organized to take care of this part of the meeting.

Is There A Complex-Ore Problem?

A Symposium on the Economics and Metallurgy of Mixed Base-Metal Sulphide Ores, Showing Present Status and Future Prospects of This Branch of Ore Treatment

A great deal is being said these days about "complex ores" and the "complex-ore problem," having reference to mixtures of base-metal sulphides and their profitable treatment. The impression prevails in some quarters that these ores are not amenable to present methods of treatment; that there are "millions of tons" of such ores; and that there is a distinct need for new treatment processes. In order to get a broad view of the real situation, and to ascertain to what extent the above impressions are correct, we invited a number of competent metallurgists and engineers to join in a symposium on the subject. The response has been gratifying, showing as it does a keen interest in the subject, and presenting a number of points of view. We give herewith a part of the contributions received and will present further views in our next issue. When all the views have been published we shall give a résumé of the situation as reflected from different engineers in various parts of the country.

In order to direct the line of inquiry we submitted a list of questions, which appear below, to serve as a general guide in approaching a subject which is admittedly broad and comprehensive. The reader will observe unanimity of opinion on some points, and diversity on others; all are interesting.

1. Is there a "complex-ore problem," and what, in your opinion, constitutes a "complex" ore?
2. Would such ores be amenable to present methods in the hands of skilled operators, or is there a need for new methods of treatment?
3. Do you believe there are many mines now idle which could produce a considerable tonnage of such ore if suitable methods of treatment were known?
4. What element or quality of such ores makes them refractory to present processes?
5. What methods or processes do you regard as probable solutions of the problem (mechanical, hydrometallurgical, electrometallurgical)?
6. To what extent would microscopical examination of such ores be of material assistance in suggesting proper methods of treatment?

W. G. Swart:—1. Yes, there is a complex ore problem in the sense you intend the inquiry, "complex ore" meaning a sulphide mixture. It would perhaps be better to say that there are complex-ore problems, because neither ore bodies nor treatments therefor are twice alike. This rather important fact, often overlooked, makes it difficult to say yes or no to all your questions without qualification.

2. By far the greater part of such ore can be successfully handled by mechanical methods, such as concentration, flotation and separation. "Successfully" in this instance means "profitably." Results are always better where skilled operators are employed. Failures may usually be traced to unskilled financing, engineering or operating. No one claims that mechanical methods are perfect or broadly economical, but they pay dividends. Some ores now in sight cannot be treated by mechanical means. Such ores must await new methods.

3. Not many mines containing complex ore are idle because of lack of suitable metallurgical processes. Idleness is due more to such conditions as inaccessibility, heavy snow, poor transportation, high freight rates, high fuel, distance from market, lack of water, poor financing, bad management, ignorance, and improper mining and milling methods. The complex-ore bodies of America, with two or three notable exceptions, are small, scattered and dissimilar, and this is the real complex-ore problem. It must be solved not generally, but each case individually.

4. I should say that fineness of crystallization, while not the sole cause of "complexity," probably causes the most trouble to mechanical processes.

5. Mechanical methods will hold their own for some time to come because results and costs can be safely and closely predicted from experiment and because small economical plants are possible for small ore bodies. Plant cost on most of the proposed chemical and electrical methods is prohibitive for small mines. Central custom plants like the present lead and copper smelters may eventually be established, but this will still leave the low-grade, inaccessible mine without an outlet.

6. The microscope always has helped the metallurgist and always will. The difficulty here is again the danger of generalization. Each ore will have to be separately studied and its proper mechanical treatment worked out. It is no uncommon experience to find today's mill supply from the second level a very different ore and problem from yesterday's tonnage from the fourth level. It by no means follows, either, that mixing the two for an average feed gives the best results.

My general conclusions are that the problem is not one of processes so much as one of economics of mining—the location, size and character of the ore bodies. Show the metallurgist the ore and he will successfully treat it, *if there is enough of it.*

Denver, Colo.

Robert N. Bell:—There is a "complex-ore problem." As to what constitutes a "complex" ore, I would say that I have a deposit in mind, where a considerable tonnage is available, in which the ore consists of zinc-lead-iron sulphide forming an amorphous blend, with absolutely no crystalline grain except scattered crystals of pyrite that contain equal proportions of lead-zinc-iron sulphides. There is hardly any gangue material. The ore breaks with a conchoidal fracture, and has a grain like broken steel. Some able metallurgical talent has tried to separate the more valuable minerals in this ore, but without results worth speaking of. Of course, it could be smelted, but the zinc would be wasted and the lead would not carry the cost of shipment and treatment. A similar condition prevails in less degree in a fine-grained crystalline ore from the Morning mine, at Mullan, Idaho, where successful advances have been made in separation through improved flotation methods.

As an example of refractory ore I would cite one which is a solid mass of arsenical pyrite, almost grainless in texture. It constitutes about 60 per cent of the ore-body, and contains about 6 per cent lead, 12 per cent zinc and 6 oz. silver per ton, the latter associated with the lead. This ore has resisted all attempts at separation by leading metallurgists, but is now undergoing further experimentation.

In my opinion, hydrometallurgical and chemical means will have to be employed for the successful treatment of such ores.

Microscopical examination has been of material as-

sistance in the advances made in treating ores from the Coeur d'Alene (Idaho) district.

Boise, Idaho.

George E. Collins:—1. I suppose a "complex ore" is any ore which contains several valuable metals which have to be separated, or partly separated, in order to obtain marketable products. Accepting such a definition, there would be as many "complex-ore problems" as there are complex ores. Popularly speaking, complex ores are mixtures of zinc sulphides with lead, iron or copper sulphides.

2. Such ores are amenable to (imperfect) separation by known methods, or combinations of methods, but usually with partial success, because of the losses incidental to separating and marketing. In other words, but a small portion of the gross value of the metals contained is received by the original producer of the ore. The other methods proposed, such as electric smelting, chlorination and various forms of leaching, have not been sufficiently tried out under actual working conditions to justify positive conclusions as to their scope, or to enable the metallurgist to figure on the commercial results to be realized from them. They are as yet possibilities (or probabilities), rather than practical processes.

3. There are great numbers of mines now idle which could produce a large aggregate tonnage of complex ores, if it were commercially remunerative to apply known methods, or combinations of methods, or if other methods were available which could be successfully applied in small and inexpensive units.

The greatest difficulty is the small size of the ore-bodies in the vast majority of mines; which will warrant neither venturing experimentally into new metallurgical fields, nor even the installation of known processes, calling for expensive equipment. The majority of mines are small, and their life uncertain. Mines which will produce large tonnages are rare, equally when the ores are complex, as when they are simple.

So far as I know, there are few deposits now unworked of sufficient magnitude to justify experimenting with such processes as electric smelting or chlorination; which, even if eventually successful, are likely to be expensive luxuries for the pioneer. The details of such processes should be worked out by large existing producers, or by associates of such producers. Perhaps this might even be a proper field for the activity of the United States Bureau of Mines, in view of the possible value of these methods in aiding the conservation of the mineral resources of the nation.

4. I do not know of any "element or quality" of complex ores as above defined which "makes them refractory to present processes," excepting, perhaps, the tendency for the constituent minerals to be closely interlocked with each other, and in some cases with gangue of similar specific gravity. It is mainly a matter of costs and market values.

5. At present, I think we are dependent on mechanical ore-dressing methods, with flotation as an alternative; in either case supplemented by magnetic or electric separation.

Eventually, I believe that electric smelting, along the lines suggested by Johnson, will be feasible, and perhaps also chlorination and leaching. The two former I think will usually be applied to ores on which a rough preliminary dressing has been made by flotation or concentration, for I cannot conceive of the costs being low enough to warrant omitting preliminary treatment. For the moment, not having been sufficiently tried out to afford definite data as to field for successful application and costs, they are outside the sphere of the engineer, but may enter it before long, especially in districts where cheap power is available.

6. Microscopic examination, with low power, is of great value in mechanical concentration, and also in electrostatic work. In both these lines it may be regarded almost as a standard practice. I do not know in what way it can be of value in solvent or fusion metallurgical methods.

Denver, Colo.

G. H. Clevenger:—There are, in non-ferrous metallurgy, a number of "complex-ore" problems, and inseparably associated with them, and towering above them, and of even greater importance, there is a low-grade problem. The metals can be recovered from all ores by known processes; but it is not always possible to do so at a profit. The demand for the metals and the exhaustion of many of the higher grade deposits, together with the economic necessity of producing them at a profit is responsible for the "complex" and the low-grade ore problem. There is also the ever-present possibility of recovering the metals at a still greater profit from ores now being profitably treated. Call this problem what you will, so long as the percentage of extraction is below 100 and the working costs are greater than 0 the metallurgist has it staring him in the face.

The term "complex ore" is used in so many ways that it is difficult to give a single definition which will hold in all cases. It at once conveys to the metallurgical mind an intimation of difficulties to be met and overcome. In the most general sense a "complex ore" would be one the constituents of which, and their occurrence, were such that the metals could not be readily recovered from it by ordinary methods of treatment. The extreme case would be one in which the ore cannot be treated by any known process at a profit. An ore ceases to be "complex" when difficulties connected with its treatment are satisfactorily overcome. For some time metallurgists have associated the "complex" ore problem more particularly with ores containing zinc associated with other metals.

All ores are amenable to present day smelting processes as applied for the recovery of the more common metals, copper, lead, gold and silver. This comes about not only through the flexibility of the smelting operation, but also through the present-day practice of locating large smelting establishments at railway centers, which makes possible the blending and mixing of a variety of ores. Thus, if one ore contains a high percentage of some objectionable element it is diluted by smelting with other ores. The large smelting interests located at central points, where they can draw ores from a number of districts, therefore known nothing of the so-called complex ore problem as regards these metals. True it is that they have their troubles, and that some ores are more easily treated than others, but notwithstanding this all ores containing copper, lead, gold and silver in payable quantities can be satisfactorily treated.

Zinc is troublesome in the smelting operation for the other metals, but as has been mentioned, even this difficulty is readily overcome by smelting very zincky ores with ores which are low in zinc, so the total mixture does not contain zinc in excess of that which can be economically handled in the smelting operation. While it is true that zinc does not prevent these other metals from being recovered, at the same time, with present-day smelting methods all such zinc, with the exception of the small amount recovered by the bag

house, as in the Lewis and Bartlett process, is lost in the slag and the fume. Herein lies one of the greatest weaknesses of our present day smelting practice, in that there is a distinct economic waste going on as regards zinc, much of which will never be recovered. It must be conceded that sooner or later we must look to these sources for a large portion of our zinc supply. Therefore, this problem is of constantly growing interest, and judging from the amount of effort which has been expended upon it in the past few years, and is now being expended upon it, a satisfactory solution is not far distant. Therefore, as regards complex copper, lead, gold and silver ores, which are commonly known as smelting ores, the great problem is the recovery of zinc, and to a less extent other by-products.

In this connection I have in mind a California mine which for a number of years operated profitably, recovering copper and the precious metals by the ordinary copper smelting process. The zinc contained in this ore, which was entirely lost in the smelting operation, calculated at the ordinary market price for zinc, had a greater value than the other metals combined. If there were a satisfactory process for recoverihg zinc in conjunction with the other metals, this mine could greatly augment its present profit.

Much has been accomplished in solving this problem by separating a marketable zinc product by various concentration methods. Hydrometallurgical processes for the recovery of zinc have been beset with many difficulties and although an enormous amount of money has been expended in their exploitation, there is at present no plant in regular commercial operation which employs a process of this type. Electrothermic processes have received their share of attention, but opinion differs regarding their commercial applicability. Here the problem seems to be in the condensation of the zinc vapor.

When an ore contains too small a proportion of the valuable metals to render its shipment to a smelting plant for treatment profitable, the next possibility becomes local treatment. This may take the form of concentration, which produces a product of high enough grade to ship; and thus a profit is derived from an ore which otherwise could not be treated. In the past this has been the only alternative with low-grade copper and lead ores, but at present there are a number of hydrometallurgical processes for low-grade copper ores which are being rapidly developed.

For years the ordinary process of plate amalgamation for the recovery of gold has been practiced in the most remote of mining camps. It is perhaps the simplest and cheapest of metallurgical processes but it is suited only for the recovery of gold occurring in the native state. While little more could be desired of a process in point of simplicity, yet as ores have changed in character through the discovery of new occurrences, and the attainment of greater depth upon the old deposits, simple ores became "complex" ores as regards plate amalgamation.

These ores therefore presented the low-grade ore problem as regards smelting, and the complex-ore problem as regards the simple process of amalgamation. The cyanide process practiced either singly or in combination with other operations as amalgamation, concentration, roasting, etc., has done much to solve the low-grade ore problem of smelting and the complex-ore problem of amalgamation, as regards gold and silver ores. But complex-ore problems have arisen in the operation of the cyanide process; for example, suppose we have an ore containing some copper, in which gold and silver predominate, which cannot be profitably smelted. If there is a sufficiently high percentage of copper in the soluble form, such an ore cannot be cyanided on account of the copper, which not only interferes with gold and silver extraction, but also causes a prohibitive cyanide consumption. The inability to treat gold and silver ores containing copper is today one of the weak points of the cyanide process, and may be said to be one of its "complex-ore" problems. Another "complex-ore" problem of the cyanide process is a most perplexing difficulty which arises in connection with the application of the cyanide process to the treatment of certain silver ores. This problem is not, as many have supposed, associated with the treatment of the unoxidized or lower-level sulphide ores, but is a result of oxidation either through natural causes during or after ore deposition, or of oxidation artificially induced as in the oxidizing roast. This difficulty frequently arises in treating ores containing the oxides of manganese and the manganese has therefore frequently been held to be the culprit; but there are reasons for believing that the silver is not in combination with the manganese in such cases.

The lack of a skilled operator will cause the failure of any process; but as there is no lack of skilled operators for all metallurgical processes, the owner has no one but himself to blame if his metallurgical ship goes aground on this shoal.

The mining engineer is best qualified to answer the question regarding the amount of complex or low-grade ore which mines now idle could produce. Judging from what I myself have observed and from what mining engineers of extensive experience have told me, the amount of such ores awaiting a satisfactory process of treatment has been greatly exaggerated. It is no unusual thing for tremendous deposits of two and three-dollar ore to shrink into nothing upon careful examination. Therefore the legitimate complex and low-grade ore deposit must be carefully sorted out from the many supposedly valuable deposits awaiting satisfactory methods of treatment. The first step in an investigation of this kind is to retain a competent mining engineer. Frequently he will be able to complete the investigation without the aid of the metallurgist.

Although the mechanical side of metallurgy has reached a very high stage of development, unquestionably far in advance of the chemical side, one would scarcely venture the opinion that there was nothing further to be accomplished in this line; but it does seem probable that the most important developments of the future will be made upon the chemical side of the subject.

There have been a great variety of electrometallurgical processes tried on a commercial scale in the Western mining states; but the performance in most cases has been disappointing. Notwithstanding previous failures there are many of us who still hope for important developments in this direction, but it is impossible to predict along just what lines.

Hydrometallurgical processes are of rapidly increasing importance and in the course of time they will take first rank for the recovery of certain of the other non-ferrous metals, as they have done with gold and silver through the cyanide process. This seems to be particularly true of copper. The incentive for this development is due, on the one hand, to the high losses of metal occurring with present-day concentration systems, as applied to the treatment of the low-grade ores; and on the other, to the increasing difficulties with the smelter-smoke problem. It is my belief that one great solution of the smelter-smoke problem, as well as of overcoming the trying losses which occur in the concentration of low-

grade copper ores, will be the operation of a hydrometallurgical process or processes, which will recover directly a high percentage of the copper without disturbing sulphur, arsenic, etc. When this happy day arrives, we will take out the valuable constituents of the ore without in any way altering the objectionable gangue minerals. After all, the best solution of the vexatious smelter-smoke problem is not to make the smoke. Are we hoping for too much, to expect that in the future a solvent will be found for copper in its common combinations, which will remove the copper from most ores regardless of whether the gangue is largely silicious or basic, and without disturbing the major portion of the sulphur and arsenic? I think not. Consider what is now an accomplished fact through the cyanide process with gold and silver ores. It is now possible in most cases to treat concentrates containing gold and silver, consisting largely of the sulphide minerals, more economically than they can be smelted and without disturbing the sulphur. The sulphur goes onto the dump in the form that it came out of the ground, minus the gold and silver. Every day we hear of a new application of this process, even to very complex ores which it was formerly thought were either too complex or too high-grade to treat by such methods, therefore must be smelted. Perhaps the most convincing argument in this line would be to refer to what has been accomplished in treating the high-grade ores of the Cobalt district, where ores which carry approximately 39 per cent of arsenic, together with many other impurities, and on an average about 10 per cent of silver, are today more economically treated by a hydrometallurgical process than by smelting, and without contaminating the atmosphere with arsenic. I do not wish to be understood as predicting that the smelting of copper ores will be entirely supplanted by hydrometallurgical methods, for there doubtless always will be cases where hydrometallurgical methods cannot be applied to the best advantage; but the extensive development of hydrometallurgical methods is going to prove a solution of some of our present-day ore-treatment problems.

Microscopical examination will eventually have its place in the working out of the problems of ore treatment, but just at present there is a serious difficulty in its application on account of the fact that the specific effect of the various minerals has never been thoroughly worked out for the different processes. However, it must be remembered that at best microscopical examination would only assist in locating the difficulty, and that the major portion of the problem lies in finding and applying the remedy.

Palo Alto, Calif.

H. A. Guess:—1. There always is a complex ore problem, but of late no doubt more prominence is given to it as the simpler ores get scarcer. A complex ore from the ore-dressing viewpoint is one difficult to separate into marketable products, either because the minerals of the different valuable metals are too intimately and finely mixed, or are of about the same specific gravity, or have a gangue or a portion of it, of about the same specific gravity as the minerals.

2. It is doubtful if the present processes, even the newer ones, will satisfactorily treat the more difficult of these complex ores.

3. There are, no doubt, some mines now idle which could produce a considerable tonnage of such ores if suitable methods of treatment were available.

4. The cause of refractoriness has been touched upon in 1.

5. Each of the three types of processes you list will doubtless contribute toward successful treatment of difficult ores.

6. Where the minerals are very finely and intimately mixed, microscopic examination of the fine screen sizes, say of tailings, often aids in showing how fine it is necessary to crush to effect complete liberation of the minerals.

New York City.

F. W. Traphagen:—1. There certainly is a "complex-ore problem." Complex ores are: First, ores containing several metals in such intimate mixture that direct smelting or ore-dressing methods are inapplicable, and in which no one or more metals can be sacrificed commercially for the recovery of the others. Second, ores in which the losses by dressing methods are so great, because of the production of rich slime, or tailing, or mixed concentrate, that ordinary methods of treatment would yield little or no profit. Third, ores from mines so situated geographically that the ore or concentrate therefrom would yield no profit because of high freight and treatment rates.

2. Undoubtedly improvement could be made in present practice by skilled operators, but there is not as much room for progress in present methods, particularly mechanical processes, as in the development of new methods.

3. There are undoubtedly many properties that would yield large tonnages of ore that cannot be handled under existing conditions, if suitable methods of treatment were developed.

4. No particular element is responsible for the refractory nature of complex ores. Zinc is objectionable in lead and copper smelting for several reasons, and, in addition, is completely lost in those operations. Lead is not saved in modern copper smelting practice. The difficulty in treating complex ores lies in the fact that our metallurgical processes save but a few metals and sacrifice others of value. This is the principal phase of the "complex-ore problem."

5. The solution of the problem lies in the development of some method involving a combination of hydro- and electrometallurgical practice. The process should be applicable at or near the mines, and produce metals of products of sufficient purity to be marketed at once, without the necessity of sustaining additional charges to make them sufficiently high grade to market.

6. The microscope is of great value, especially as indicating whether dressing methods may prove valuable. I had one sample of complex-ore in which the minus 200-mesh grade showed under the microscope an intimate mixture of blende and galena. Such a mixture could not be separated by concentration.

Golden, Colo.

L. S. Austin.—In addition to defining "complex ores" as mixtures of base-metal sulphides, I might further limit the definition to cover mixtures, in the treatment of which the extraction of one metal interferes with the recovery of another. Thus, a lead or copper ore containing gold and silver only, while complex, presents no difficulty in the extraction and separation of its constituent metals. Again, an ore that is a combination of chalcopyrite, pyrite and galena, with gold and silver, should, after roasting, be quite suited to blast-furnace treatment. But the complex ore regarding which the question of treatment has been in dispute, appears to be one containing zinc as blende, in addition to the sulphides noted above.

Practically, either in copper or lead smelting, zinc is a detriment and so is penalized. After roasting,

such an ore can be treated in the blast furnace, but the zinc is never recovered. It principally enters the slag; in part it goes into the matte, and in part is volatilized, forming accretions in the shaft of the furnace. In consequence of its volatile nature it takes away silver that should have gone into base bullion or matte. In silver-lead smelting, with a charge high in zinc, one has to modify the type of slag, making it more irony and less silicious than if it were zinc-free; and so, where fluxing iron cost money, zinc stands for a higher smelting expense per ton of materials of the charge. To keep such a slag fluid requires a little more fuel. In smelting copper ores the same drawback occurs, though in less degree, since the zinc is more easily volatilized. That the presence of zinc constitutes a real detriment is shown, in that in Colorado it is penalized when the ore contains over 10 per cent., at the rate of 50 cents per unit (1 per cent). In Utah zinc is free up to 10 per cent, and sometimes to 17 per cent; above that limit a penalty of 30 cents per unit is incurred.

To aid in the solution of the difficulty in the reduction of zinc-bearing lead sulphides, the United States Smelting, Refining & Mining Co. have in operation at their Midvale plant a concentrating mill where they separate the lead, and from the concentrates made in the wet way, the zinc by the Huff electrostatic machine. For ores suitable to this method of concentration they will then pay as follows:

For metals, the gold at $18.00 per oz.; 80 per cent of the silver at the New York market price; 80 per cent of the lead at that market price per pound less 1½c. Ten per cent of silica is charged for at 12c per unit or $1.20 in all; 60 per cent of the iron is paid for at 6c per unit, and 30 per cent of the zinc at 2c per pound.

In silver-lead smelting, copper, when present in the ore, goes into the matte, and is in consequence recovered. In copper smelting, on the other hand, if lead is present it is volatilized and no attempt is made to recover it—it is a complete loss. Provided it is primarily a copper-bearing ore, this loss need not be a serious one, and it is better to lose two or three per cent of lead rather than to adopt some special process to recover it, or attempt to send it to some silver-lead works to obtain such recovery.

In the year 1903 the American Smelting & Refining Company smelted ores of a gross metal value of $33 per ton. At the end of 1911 they were treating ores of an average gross metal value of but $16 per ton, some of course high in zinc. When we consider that from this value of $16 is to be taken the cost of mining, freight and treatment there seems but little margin to compensate the mine owner.

Mr. Johnson, of the Continuous Zinc Furnace Co., has lately been bringing to our attention his electric process for the recovery of all the metals in a complex ore, containing not only the base metals, zinc, lead and copper, but the contained silver and gold as well. He has done this with a great degree of success, but at a cost of $10 to $12 per ton. Now it is obvious that the complex ores awaiting new methods of treatment "of which millions of tons exist" would not stand such expense for treatment, and it would probably be found that their contained metals would not aggregate in value a figure that would bring them in the category of ore, if such a mineral were to be defined as one commercially profitable.

As an evidence of the complexity of many ores treated at custom silver-lead works, let us consider the constitution of the copper-lead matte produced by them. This matte when produced is roasted, sintered and again returned to the furnace. Each time it goes through the furnace it picks up impurities from the charge. Finally, when its copper content has reached a proper figure, it is withdrawn from the circulation, separately smelted to yield a matte of 40 per cent or more copper, and sent to a refinery for converting, yielding blister copper and bag-house fume.

An average analysis of the matte is as follows: Pb, 26.9 per cent; Cu, 43.1 per cent; Ni and Co, 0.4 per cent; SiO_2, 0.3 per cent; Fe, 8.0 per cent; Zn, 2.5 per cent; S, 15.5 per cent; As, 1.7 per cent; Sb, 0.76 per cent; together with Au, 0.17 oz. and Ag, 98.1 oz. per ton.

The fume yielded in converting is found to contain: Pb, 52.5 per cent; Cu, trace; Zn, 3.0 per cent; S, 5.4 per cent; As, 14.2 per cent; Sb, 1.6 per cent; Te, trace; and Ag, 10.0 oz. per ton.

Thus, besides the metals we expect to find, there is present in the matte nickel and cobalt as well as arsenic and antimony; in the fume are both of the latter metals, a trace of tellurium and much arsenic. All these metals are detrimental, and when in sufficiently pronounced quantities are penalized. Another metal, more volatile than zinc, and entering the bag-house fume of the blast-furnaces, sometimes to the extent of from 15 per cent to 20 per cent, is cadmium, not to mention arsenic. Since the flue-dust goes back to the blast-furnaces for the recovery of lead, these metals continually climb to higher percentages in the closed circuit until, like an electrolyte, they must be removed for special purification.

There is no question to my mind, that with the advance of metallurgical methods, the day will come when many of these low-grade ores will be commercialy exploited, but the day is not yet. In looking for the best methods of treatment no doubt microscopic as well as chemical methods of analysis will be of much aid. In what directions reduction methods will develop it would be hazardous to suggest, but as I believe, not in the line of pyrometallurgy.

Salt Lake City, Utah.

Edward S. Wiard.—There is a complex-ore problem. I would define a complex ore as a mixture of two or more base-metal sulphides in gangue, at least two of which are of commercial value.

Present results from the treatment of such ores would be improved by skilled operators. There are no new methods in use at present, but it might confidently be expected that improved processes would arise from a more refined employment of present methods.

The number of available mines with complex ores, now idle, from which refined methods of ore treatment would win a profit is small, but they do exist.

A difficulty encountered in treating these ores is that the commercial sulphides have too nearly the same specific gravity. As the minerals become more finely disseminated they become more refractory. Refractoriness in such ores may be said to be represented by the product of the first factor times the square of the second.

In my opinion, mechanical processes will be more generally applied in the treatment of these ores.

The use of the microscope in connection with complex ores will be of value only as it gives better vision than can be had with the naked eye.

Denver, Colo.

R. C. Canby.—1. Literally speaking there is undoubtedly a "complex-ore problem" as applied to ores such as those to which your terms have reference; that is, the base-metal sulphides, especially where these sulphides are so finely disseminated as to re-

quire particularly fine grinding to separate the different sulphides from one another. More broadly speaking, however, the entire field presents problems, the gradual mastering of which is bringing under profitable treatment ores which were previously of no commercial value. Such a base-metal sulphide would be "complex" when containing zinc, especially in combination with copper, particularly when the sulphides are finely disseminated.

2. Strictly speaking the amenability of these ores to present processes is not a question of operating skill.

3. Many mines are now operating at an economic disadvantage, and there are also many deposits which will eventually develop into mines as metallurgical progress is made.

4. In the ores referred to, it is unquestionably the sulphide of zinc which renders them "refractory." It is not altogether, however, owing to the difficulties arising from the presence of the zinc which calls for a more suitable method, but because in the usual treatment of such complex ores, at present, the zinc content not only incurs treatment penalty but is also lost, either in the concentration or in the smelting.

5. Of the new or unusual methods, "flotation" is already producing enormous quantities of zinc heretofore lost, and is making possible sulphide savings which were previously impossible. Flotation, like other forms of mechanical concentration, however, is only a partial or preparatory step. Gradual improvements in the methods of smelting these concentrates will be made to suit the various products and local conditions. I am inclined to believe that electrometallurgical treatment will be brought about eventually through the development of hydroelectric power, making cheaper power available.

6. Microscopic examination of finely disseminated sulphides reveals much of interest, not only as to the minerals present, but as to the mineralogical history of the ore. It seems that the microscope is, however, more interesting to the mineralogist than to the metallurgist. Minerals so finely disseminated as to become microscopic evince their close dissemination by a more cursory examination than that of the microscope.

Miami, Ariz.

E. L. Godbe.—1. Unquestionably there is a "complex-ore problem." In the generally accepted sense, a complex ore is one containing a very fine and intimate mixture of base-metal sulphides, principally, zinc, lead and iron, the separation of which is difficult or impossible by gravity methods of concentration. Many other ores are complex in their nature, by reason of the fact that well known metallurgical methods will not work them to advantage, yet these are not generally regarded as coming under the caption "complex ores."

2. In the very large majority of cases, the so called complex ores, I think, are amenable to present processes, and the only thing necessary to apply them profitably is metallurgical skill in working out the various details, the shaping of economic conditions, and in the acquisition of sufficient capital to construct proper plants. The average mine operator is very skeptical in regard to the adoption of new methods, owing to the fact that so much money has been lost in untried and impractical processes in the hands of unskilled metallurgists. On the other hand, there are certain ores the minerals of which are so intimately associated as to be almost chemically combined, and for this kind of ore there seems to be little doubt but what new methods will have to be devised.

3. There are a great many mines scattered throughout the West which can produce a very large tonnage of complex ores, and very profitable results will follow the adoption of suitable methods of treatment. In order to work out and solve these problems the most essential thing, in my opinion, is careful experimentation in the hands of competent metallurgists. The great difficulty experienced so far in the working out of these problems is the inability to find properly equipped laboratories where all the known methods of treatment can be tried on any particular ore. As every one has its own peculiar characteristics, no operator can tell how any process will work, except by trying it, and it is safe to say there is not a single laboratory in the United States where all of the various known methods of treating complex ores can be definitely tried out. If the miner could take his ore to, say a first-class government laboratory, one that is thoroughly equipped with facilities for testing out all of the modern improved methods, such as flotation, roasting, wet and dry separation, gravity concentration, to say nothing of the still newer methods such as volatilization of sulphur, reduction of the metals to the metallic state with subsequent concentration, volatilization of zinc and lead and condensation in the metallic as well as the oxide form, etc., there is little question but what a satisfactory solution of almost any complex-ore problem could be found. Furthermore, the report of such a laboratory would enable a mine owner to acquire sufficient capital to build proper reduction works. After having been once installed, a laboratory of this character should be self supporting.

5. For the real complex ores, without doubt, the mine owner will have to look to the hydrometallurgical and electrometallurgical methods for relief. Great progress is constantly being made in the development of these processes, and while to-day it cannot be said that any one of them is an established success, yet they certainly do give bright promise for the future. There are so many methods suggested along these lines, the application of which will doubtless be confined to certain particular kinds of ore, that it would be difficult to say just which ones present the greatest promise. As electricity is rapidly becoming an important factor in almost every hydro-metallurgical process, it is safe to assume that its use will largely increase.

6. Microscopical examination would undoubtedly greatly facilitate the diagnosis of any particular ore, but in itself I do not think it will play a very important part. In my opinion, what is most needed to solve this complex-ore problem is properly equipped laboratories, competent operators, plenty of money for experimentation, intelligent working out of economic conditions, and, last but not least, more faith on the part of mine managers and owners.

Salt Lake City, Utah.

A Manual of Electrical Testing is the subject of a new forty-eight page bulletin, size 8 x 10½ in., issued by the Wagner Electric Mfg. Company of St. Louis. Besides describing the line of portable instruments manufactured by the Wagner company, this publication describes various types of electrical instrument movements, the errors to which they are subject and gives suggestions for their handling and care. The methods of making electrical test on alternating-current and on direct-current motors and generators and on transformers are described at length and illustrated by comprehensive and instructive diagrams.

The Metallurgical Engineer in the Steel Works

BY JOHN HOWE HALL

In their attitude toward the employment of metallurgical engineers, managers of shops may be roughly divided into three classes: those who utterly disbelieve in metallurgists, those who employ one for show purposes, but pay no attention to his recommendations, and those who believe that his efforts, properly directed, are of value.

Managers of the first class say "Look at so-and-so, who worked up from the bottom and ran the great shops at such-a-pace! You didn't catch him bothering his head with fellows with 'highfalutin' notions. Practical man, he was, and employed only practical men!" Of course, there are at least two points in the case of their hero that they overlook. First, he made his way to the top in pioneer days, when the margin of profit was large and expert knowledge limited; second, in his later career, it is a hundred to one that the great magnate made use of the services and advice of experts in various lines, in order that his shop might continue to make money in times of increasing competition and decreasing margins of profits, and to keep abreast of its competitors in the quality of its output.

In dealing with managers of this class one hears the words "Practical Man" about every third sentence. The definition of a practical man seems to vary more widely than any known variable in a steel works. Reduced to its lowest terms and defined by negative methods, it appears that to a great many managers any one who submits for consideration a proposal based upon a reasoning process which the manager does not understand, is *not* a practical man, and should be treated accordingly.

The second class, fortunately rare, is composed of those who do not believe in metallurgists, but who see successful shops employing them, and in order to gain a reputation for progressiveness, engage an unfortunate individual to play by himself in a corner and be exhibited with a flourish to visitors—"Our research laboratory, you know, where our new processes are worked out." The vistor is much impressed. Managers of this class take such elaborate precautions to keep the metallurgist from all contact with the actual routine of the shop, as to give the impression that they would be pained and grieved if the unfortunate man actually succeeded in surmounting the barriers raised around him and contributing something of value to his employers.

Coming now to those who believe that the metallurgist can be made of value to his employers, we find wide differences of opinion as to how he should be made use of. To take the widest extremes, let us consider the manager who believes that his metallurgist is of value only to conduct "post-mortems" upon material that has failed in service, and the manager who believes in obviating the necessity of post-mortems. It is often said that the methods of the metallurgist are of value only as a post-mortem. Stripped of the specious pleas that always accompany the statement, this means that the knowledge that is capable of explaining the failure of a piece of work, could not have foreseen that failure if applied to the object before it was shipped. We see at once that if this is true, then it must be a fact that all causes of failure are so hidden in the objects manufactured that they can not be detected without destroying the objects. It requires but a slight stretch of imagination to see how false is this assumption.

The causes of failure in service will be of two classes, those that could have been discovered by examination of the material before shipment, and those that could not. In addition, of course, there will always be the "mysterious" failure to which we shall refer again a little later. Granting that the metallurgist should only conduct post-mortems, ascertain the causes of failure, and point them out to his employers, on whom is to fall the burden of making sure that the product thereafter is free from the defects that have been found to cause failure? For unless failures are to be lessened, surely the post-mortem itself is a waste of time and money. There is no profit, and but poor consolation, in knowing why a piece of work failed, unless we hope to prevent the failure of other pieces from the same cause.

Many of the causes of failure disclosed by post-mortems are of a nature that only the expert can apprehend. How shall the practical men in the shop be able to recognize them in the future, and guard against their recurrence? Again, if the cause of failure be plain to the ordinary shopman, how far can we rely on his intelligence to understand the necessity of condemning the material suspected? His job is to produce the maximum tonnage of material fit to ship; the more material is condemned, the less his output. Hence his whole mental attitude is such that he is sure to throw the weight of his influence toward shipping everything that passes a casual inspection, and taking chances on the issue. Both by training and by inclination, he is the man of all men about the shop who is least likely to be active in condemning poor material.

It is evident, then, that the man who conducts the post-mortems should be in a position to recognize defective material before it is shipped—if possible before it is finished. To ensure this, all processes in the shop in which inferior work may be done, *must* (not may) be subject to his check.

Moreover, there is another side to the question. In conducting a post-mortem, a man who does not have at his disposal a mass of data on the properties of the materials the shop manufactures, is forced to rely solely upon a general knowledge of the subject, based upon the work of independent investigators, which is all too scanty, and in but few cases applies directly to the problem in hand. It is then almost impossible for him to ascertain the true cause of the failure. Here we see one of the serious disadvantages of relying upon examinations of failed material, made by an expert who may be a thousand miles away, and familiar only in a general way with the materials the shop produces. His opinion is necessarily couched in rather general terms, often covering several possible causes of failure, because in most cases he cannot be really sure of the exact one. He fires a shotgun into the flock, as it were, instead of picking out with a rifle the particular bird that is doing the damage.

In order to form an opinion of value from a post-mortem, therefore, the metallurgist must have data as to the nature of the material which the shop has been producing, and as to its behavior in service; and in order to apply the conclusions obtained from a post-mortem to the material being made, that material must be constantly subject to the metallurgist's check. Thus either way we look at the matter, we see that the three functions of the metallurgist are inseparable one from the others. He must conduct post-mortems on failures, check the material being manufactured, and apply the knowledge gained from

both sources to the improvement of the product. The material that can be recognized as liable to failure from a cause identified by post-mortems, can then be held up, and its failure prevented; and by tracing to their origins both this class of defects and those that cannot be recognized by an examination of the material before shipment, the failures of both classes can be minimized.

The "mysterious failures" will at first be numerous. It will be found, however, that by keeping a full record of them, and by having them constantly in mind, they will soon be recognized as falling into several classes. As data from the examination of material before shipment accumulates, light will be thrown on the causes of more than one class of unexplained failure, and the number of kinds of mystery will be greatly reduced. It may safely be said that the greater number of unexplained failures are "unexplained" solely from lack of systematically collected data upon which inferences may be based.

It is plain that if the metallurgist's services are utilized in this manner, he will work in collaboration with the manufacturing department, the claim agent and the engineering and sales departments. The routine of the activities under his control should be so arranged that the manufacturing department must submit daily to his inspection tests taken from the product itself or from coupons, that shall cover the operations of the day to a sufficient extent to guard against the possibility of the shipment of a lot of defective material. The defective material brought to the notice of the claim agent must be examined, and the cause of failure ascertained and traced to the operation responsible for the trouble. The daily testing of current product and the examination of material that has failed in service, will suggest many improvements in both processes and product. The metallurgist will co-operate with the manufacturing department in making these improvements, and with the engineering and sales departments in the marketing and utilization of improved material.

Some managers install apparatus for microscopic examination and physical testing of their material, and put it in charge of a young man without technical training. He is the information-gatherer, and his reports are forwarded to someone higher up, generally the superintendent of the shop. The latter is often too busy to use the information to the best advantage, and in many cases lacks the technical education and training requisite to a proper understanding of the problems brought up.

Again, a young man from college, with a good technical education but no experience, is given charge of the metallurgical work. Until he has acquired the necessary practical experience, the conclusions he may draw from his work are of but little actual value, for he is sure to "go off at half cock" every little while; and in a laboratory, practical experience is absorbed slowly.

The best advice to give a technical college graduate who wishes to be a metallurgist is to put on overalls and work two or three years in the shops. For a while he will learn new facts so fast that he will feel almost contempt for the technical knowledge acquired in college, and will think "Yon Yohnson" knows more than Professor So-and-So. Then he will begin to see Yon's great limitations, as well as the undoubted value of his practical information, and with the two kinds of knowledge he has acquired, will gain an understanding of the inwardness of steel works operations that will be invaluable to him and to his employers.

Such a man in a large works can be employed constantly, overseeing the activities of a number of assistants, and with plenty to keep him more than busy. The small shop, on the other hand, cannot afford to pay a salary such as this man is capable of commanding. They must, therefore, employ a younger man, college graduate or home trained, to carry on the routine work, and engage an experienced metallurgist to map out the work in the first place, to consult with the management in interpreting the results and making the changes in shop practice that may be found necessary, and perhaps from time to time to extend the activities of the metallurgical department.

Such an organization can be as simple or as elaborate as the size of the shop and the diversity of its output necessitate. It may include only the daily or weekly testing of a few samples by the chemist in his spare time, or even by an outside firm who will take the work at a fair price on a yearly basis; and at the other extreme, it may include the employment of a large staff under the direction of a resident metallurgical engineer. To-day, with the great increase of our knowledge of iron and steel and the growing demand for superior products, it is a very small shop indeed that can afford to dispense with the systematic checking up of its output by technical men of knowledge and experience, along the lines here suggested.

New York City.

The **Eastern Tanners Glue Co.** of Gowanda, N. Y., which ranks as the largest glue factory in the world, has just put in a third Swenson evaporator for making glue. This is the largest of the three outfits in the plant. The Eastern Company is noted for its labor-saving devices, including automatic industrial cars which take a certain number of hides directly from the railroad spur, stop at any predetermined vat, dump the hides into it, and then return automatically to the place of loading, alongside the railroad car. Due to the extensive use of such devices all over the plant, this company has found it possible to make glue at so low a figure that some other manufacturers, in order to tide over a sudden demand beyond immediate capacities, are said frequently to purchase glue from the Eastern company at a figure not higher than their own costs.

The attitude of the Canadian people toward the development of radium in the Dominion is reflected by the action of the provincial governments of Ontario and British Columbia. In the former, a legislative bill provides for a reward of $25,000 to the first person who discovers radium in the province in sufficient quantity for commercial extraction. The bill also authorizes the government to reserve all radium in Crown lands, with the right to work deposits, and install necessary equipment and plant. The sale of radium is to be conserved and regulated by the government. In British Columbia the prize offered for discovery of radium is $5,000, and a reserve is placed on all public lands in which radium may be found. The bill provides for regulation of the radium industry, and for a retention by the Crown of a 50 per cent interest in all radium produced.

The newly formed Chicago Section of the American Institute of Mining Engineers held its first annual dinner and meeting at the Sherman House on the evening of April 14. The officers elected were: Chairman, Robert W. Hunt; vice-chairman, J. C. Ede; secretary-treasurer, H. W. Nichols; executive committee, F. K. Copeland and G. M. Davidson. The next meeting will be in May.

Cascade Attachment for Graphite Furnace *

BY EDWIN F. NORTHRUP

If a cubical space, in which the atmosphere cannot circulate, contains graphite and is brought, by an input of electrical energy, to a temperature in the neighborhood of 1000 deg. C. or more, the atmosphere in this space becomes converted into an atmosphere which is chemically inactive in respect to graphite. If a graphite resistor, through which a separate source of current may be run, is centrally located within this space it may be brought, by an input of sufficient electrical energy, to a temperature little short of the vaporization point of graphite without any observable chemical reaction of the resistor with the atmosphere. The resistor is quite as inert as if located in a perfect vacuum. Furthermore, since experiments show the above statements to be true, the idea is at once suggested that, if the cubical space be made of steel walls capable of sustaining a pressure of many atmospheres, the vaporization temperature of graphite would be greatly raised and thus enable the artificial production of temperatures exceeding considerably the temperatures of the carbon arc.

FIG. 1—CASCADE ATTACHMENT WITH ALL PARTS ASSEMBLED

As everything tends to evaporate more readily with diminution of pressure, it seems to the writer that the use of a vacuum furnace for obtaining the highest temperatures is a step in the wrong direction, and that it would be better to aim at obtaining a furnace in which the pressure might be made very great, and the atmosphere made absolutely inert by electrically heating comparatively large masses of graphite to a moderate temperature. One may then obtain the desired maximum temperature by a rapid input of a large amount of energy in a small and centrally located resistor unit.

These ideas have been tested by the writer at atmospheric pressure with complete verification. He hopes the opportunity may offer for carrying out similar experiments at enormous pressures.

The device, which this article describes, easily melts tungsten and gives a temperature, without perceptible depreciation of the graphite resistor unit used, which certainly exceeds 3000 deg. C. It is placed in and fills the chamber of the high-temperature graphite furnace described by the writer in the January, 1914, issue of this journal. The large furnace is first brought to a temperature of approximately 1600 deg. C. and then by means of a switch the energy (obtained from the same transformer) is transferred to the heating element of the device. This heating element is a slotted tube of re-graphitized Acheson graphite. The internal chamber, which acquires a perfect black body temperature exceeds 3000 deg. C. (or less if desired), is 15 cu.c. As the temperature is produced in steps falling from a maximum temperature in an inner chamber to a lower temperature in a furnace chamber (into which the device is readily fitted or removed), the writer has called it a "cascade" attachment.

The high temperature attained in the cascade attachment with energy obtained from a single transformer, is made possible, first, because the chamber of the large furnace develops an atmosphere which gives absolutely complete protection against chemical action with graphite and, second, because the energy yielded by the transformer is first accumulated and stored in the refractories of the furnace of large heat capacity, and then additional energy, before the furnace cools much, is concentrated in a relatively small heating chamber.

The cascade attachment consists of a graphite tube which fits the furnace chamber, of two massive graphite terminals or electrodes, two nickel-plated iron terminals, a furnace cover and head piece of refractory material and a replacable resistor-unit of Acheson re-graphitized graphite. There is also inserted through the bottom of the graphite tube a graphite plug which holds a replacable crucible of graphite (or any other material) and a graphite tube which surrounds the resistor-unit and shields the walls of the furnace chamber from the intense radiation which proceeds from the resistor-unit. Fig. 1 shows the cascade attachment with all parts assembled and ready to place in the chamber of the furnace and Fig. 2 the same with its parts unassembled.

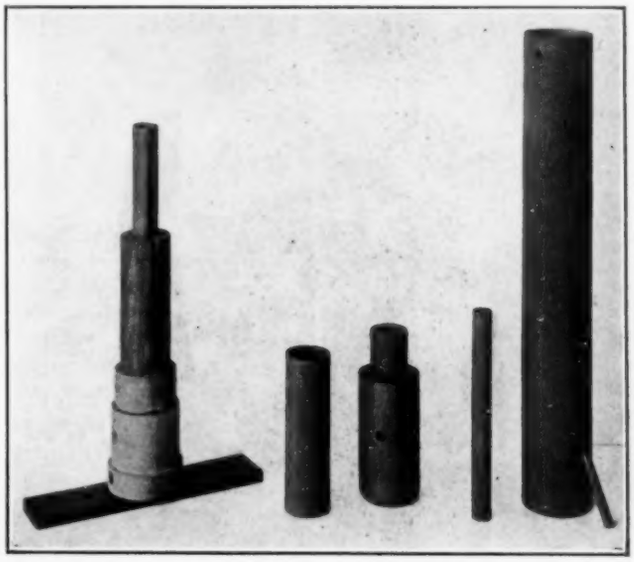


FIG. 2—PARTS OF CACADE ATTACHMENT UNASSEMBLED

The life of all the parts, except the resistor-unit, is indefinite. The resistor-unit is made to be readily replacable and is an extremely simple and inexpensive device. It consists of a tube of re-graphitized Acheson graphite, of which 7.6 cm of its length becomes heated. It is 1.55 cm internal diameter and 1.75 cm external diameter. This tube, which is slotted on two sides, slips into cuts in the massive graphite electrodes where it is held in position with two graphite screws. The crucible is a cylinder about 1.05 cm internal diameter and 7.6 cm deep. When in position it nearly fills the chamber of the resistor-unit.

To use the cascade attachment one proceeds as follows: The crucible is removed through the hole in the bottom of the cascade attachment and filled with the material which is to be submitted to the high temperature. The crucible, filled with its charge, is then replaced in the cascade attachment and held in its proper position by a graphite pin provided for the purpose. The cascade attachment is then lowered into

*The furnace referred to is the one described by E. F. Northrup under the title, "A New High Temperature Furnace," METALLURGICAL AND CHEMICAL ENGINEERING, January, 1914.

the furnace chamber. The heavy leads which are provided are fastened with thumb screws to the iron terminals of the cascade attachment. The other ends of these leads are attached to two poles of a double-pole, double-throw switch. The furnace terminals are attached to the remaining two poles and the transformer secondary terminals are attached to the middle point of this switch. The outfit is now ready to heat. The switch is thrown to "furnace," the voltage handle of the transformer is thrown to the stud giving highest voltage and the furnace is heated rapidly with an input of about 5 kw. While the transformer is nominally a 4-kw transformer, this output is for continuous operation and the transformer is not in the least strained when made to yield 5 kw for one or two hours nor by being made to yield 8 kw to 9 kw for five to ten minutes. When the current has been on the furnace for about seventy-five minutes, a temperature of about 1600 deg. C. being obtained, the switch handle is thrown to "cascade." The resistance of the heater-unit has been so chosen that the cascade attachment will take about 8 kw.

Several experiments with the cascade attachment were made by the writer. It required a number of trials to determine the proper dimensions and resistance of the cascade resistor unit for obtaining the highest temperature with the transformer employed.

A test was made April 1 to determine how long it would take and what energy would be required to bring to complete fusion a No. 20 tungsten wire. A piece of wire about 40 cm long was made perfectly straight. One end of this wire rested in the center of the bottom of the crucible and the other end projected through a hole about 1 cm in diameter in the top of the cascade attachment. The wire was centralized in this hole by means of a small plug of refractory with a hole in its center through which the wire would pass easily. At the instant a melt occurred the fact would be made evident by the wire sinking vertically downward into the crucible. The observations actually taken are directly transcribed in the table at the end of article from the writer's note book.

A curious and unexplained phenomenon was noted. Shortly after, but not immediately after, the switch was thrown to "cascade" the furnace developed a roaring noise. This noise increased in volume and became very loud before the wattmeter indicated any increase in power input. It was not due to an arcing, as no arcing occurred. In this test the wattmeter was placed on the primary side of the transformer and, on account of losses in the transformer and secondary leads, it is thought about 10 per cent should be deducted from the wattmeter readings when the switch was on "furnace" and about 15 per cent when the switch was on "cascade."

The following data are of interest: The average input (actual) on the furnace was 4.3 kw. The time of this input was fifty-three minutes. The total input on the furnace was, therefore, 3.8 kw-hours. As the outside of the furnace was still cold to the hand practically all of this energy was stored in the furnace. The average input on the cascade was 7.1 kw and the time of input on the cascade totaled 5.7 minutes. Therefore 0.675 kw-hours of additional energy was delivered to the cascade. The last time the switch was thrown on cascade the average input was 7.1 kw for 2.2 minutes, making 0.26 kw-hours input of energy which was required to bring about 15 cu. cm of space to the melting temperature of tungsten when the temperature of the furnace chamber was, by estimation, about 1600 deg. C. The outside area of the cascade resistor unit was 41 sq. cm. At the time tungsten melted 197 watts per square centimeter were being supplied to the cascade resistor unit. The volts at the cascade terminals were 28 and, by calculation from the input, the cascade resistor unit must have been taking 295 amp. The resistance of the cascade resistor unit, including its contact resistance with the graphite electrodes, measured 0.126 ohm at room temperature. Its calculated resistance when tungsten melted was 0.098 ohm, a decrease from cold to hot of about 22 per cent. The above figures must not be taken as very precise because the wattmeter registered the power input on the primary side of the transformer and because contact resistances may have amounted to several per cent of the total cascade resistance.

An examination next day of the resistor unit showed that it had suffered no deterioration. Its surface presented a satin-like appearance which showed, under the lens, that a slight vaporization from the graphite surface had started.

April 1, 1914. Observers—E. F. Northrup, Mrs. E. F. Northrup.
Test of cascade furnace after alterations.
Resistance of cascade attachment = 0.126 ohm.
Measuring current 10 amperes. Resistance decreases slightly with increase of measuring current.

Time P.M.	K.W. on large furnace	K.W. on cascade	Notes
2.00	4.6	...	
2.05	4.5	...	Line voltage low.
2.11	4.85	...	Line voltage raised.
2.11½	5.00	...	Line voltage raised.
2.15	4.78	...	
2.26	4.7	...	
2.28	....	8.4	On cascade for ten seconds.
2.42	4.7	...	
2.48	4.5	...	Line voltage lower.
2.55	....	8.7	On cascade.
2.56	....	7.5	
2.57	....	8.	
2.57¼	....	8.1	
2.57½	....	8.2	
2.58	....	8.7	
2.58¼	....	9.	Tungsten did not melt.
2.59	4.7	...	
3.04	4.7	...	
3.15	....	8.	On cascade.
3.16	....	8.	
3.17	....	9.	
3.17¼	....	9.5	Tungsten melted. 1 hour and 17 minutes from time furnace started heating. Cascade attachment heated 2¼ minutes when tungsten melted. Opened switch.

A melt of the No. 20 tungsten wire was shown by the settling down of the wire which extended above the top of the furnace.
April 2. Examination of crucible showed that about 7 cm. of the wire had made a good melt, and the entire length at about the same instant.

Department of Physics,
Princeton University.

Vismera Pure Iron is the title of a booklet issued by the Inland Steel Co., of Chicago. Vismera pure iron is 99.86 per cent pure iron guarantee, has high tensile strength, perfect physical structure, and is rust resisting. The following analysis is said to represent regular practice: iron 99.882, no silicon, no copper, no aluminium oxide, 0.040 C, 0.004 P, 0.020 S, 0.040 Mn, 0.001 H, 0.009 g, 0.004 N. The total impurities are therefore 0.118 per cent. Vismera pure iron is made in black sheets, galvanized sheets, corrugated sheets, roofing sheets, sheared sheets, etc.

The **Mountain Copper Co.** will install two 8 ft. x 36-in. cylindrical herringbone gear driven Hardinge mills in their new concentrator at Keswick, Shasta County, California. The Miami Copper Company are at present installing additional Hardinge mills.

Pyrometer Facts is the title of an interesting little bulletin issued by The Stupakoff Laboratories of Pittsburgh, Pa., giving illustrated notes on the thermo-electric pyrometer, the wall-type galvanometer, the shelf-type and portable test galvanometer, the recording pyrometer, the "simplex" base-metal portable pyrometer, the platinum, platinum-rhodium thermocouple, the base-metal thermocouple, water jacket compensation.

The Bethlehem Steel Company is putting up a Cottrell plant to purify blast furnace gas.

The Igneous Concentration of Metallic Values from Mixed Sulphides—II

Utilizing the Fuel Value of Sulphides to Make a Sublimed Zinc Concentrate

BY F. L. CLERC

In a previous paper[1] on this general subject I have outlined the progress of the application of the pyritic idea to the metallurgy of copper, accepting the definition of a pyritic process to be one in which the heat generated by the rapid oxidation of metallic sulphides by an injected air blast is utilized to take the place of heat developed by carbonaceous fuels. The sulphides oxidized may be contained in ores as sorted at the mines, or in the mechanically dressed products of concentration, or in intermediate products of smelting operations. I have expressed the opinion that zinc smelters may profitably apply the same idea to the concentration of zinc in some ores low in zinc, forming a sublimed product rich in zinc, corresponding to the rich mattes produced by copper smelters.

This historical sketch, traced out by means of a selected class of events, namely, commercial tests on a working scale which have been carefully observed and recorded, is of interest to anyone who wishes to extend the application of the pyritic principle into other fields of metallurgy.

The main facts brought out may be reviewed. The first working test I have quoted was preceded by a long line of laboratory experiments which had determined chemical facts and measured physical constants with great precision. The results of this laboratory work take high rank as contributions to human welfare; they were essential to any industrial application. With these data at hand, small scale metallurgical laboratory experiments were tried, to solve one or more problems involved in industrial enterprises.

A striking feature in this development is the fact, clearly shown, that many years elapsed after a practical and public demonstration of the merits of the process before it was successfully introduced in practice. Still other concurrent conditions were requisite to secure its establishment on a firm basis. These were: an available supply of suitable ores, and, not less important, trained metallurgists who saw a value in the process and were able and willing to tackle and overcome the constructional and manipulative details incident to all new metallurgical processes.

The process was first introduced at particularly favored localities. The discussion of the subject by American metallurgists[2] shows in what measure the process was utilized under less favorable conditions and indicates the modifying effect of local conditions.

Before attempting to employ the process in zinc metallurgy, its development in copper smelting should be carefully studied.

Data Available and Required

Fortunately, the chemical and physical data are readily available. Some laboratory experiments are desirable in working out some of the problems involved. With the great extension of facilities for this work furnished by government, university, corporation, and private metallurgical and test laboratories, it is to be expected that this need will be recognized and filled. Some of the determinations required reach to the very essence of pyritic smelting, and will supply much needed data; for example, the determination of the effect of increasing the temperature of blast and of the rate of blowing; the composition of issuing gases; the fusibility of definite charge mixtures; the separation of matte, and the expulsion of zinc from slag and matte.

Experimental Apparatus Suggested

I subjoin for present reference a few constants involved in the study of pyritic smelting, and submit several sketches illustrating simple laboratory apparatus by means of which many results of value should be obtained. Anyone accustomed to laboratory experiments can readily improve upon the construction shown. I hope the ideas involved will be suggestive of such improvements. Fig. 1, mainly diagrammatic, shows an air meter with a tightly fitting piston, the displacement of which is read on the graduated piston rod. The pressure is regulated by the weight applied to the cross-arm, which carries the guides to ensure parallel motion. Connected with this is the blast pipe *D* containing a thermometer *E* and a pressure gauge *F*, which may be a spring gauge measuring ounces, or a simple tube measuring inches of waterhead; beyond these, on the pipe line, should be located an electric heater for the blast, shown separately at *N*, and a thermopile, represented by *O*, to measure the temperature of the heated blast. With a proper gas valve in the air pipe beyond this, and the ordinary ammeter and voltmeter connected with the electric heater, the efficiency of various electric heaters, as affected by the volume of the blast, could be readily measured. This apparatus, connected with the inner crucible *H* would be sufficient to conduct many experiments in sinter-roasting, clinkering and volatilization on commercial grades of ores, as well as on selected mixtures, with and without additions of carbonaceous fuels and fluxes. The crucible *H* should be inclosed in a larger crucible and the space between them packed with a heat insulator. The detached cover *J* of the inner crucible, with the goose-neck *K*, the equalizing tube *L* and the discharge tube *M* shows the manner of drawing off the

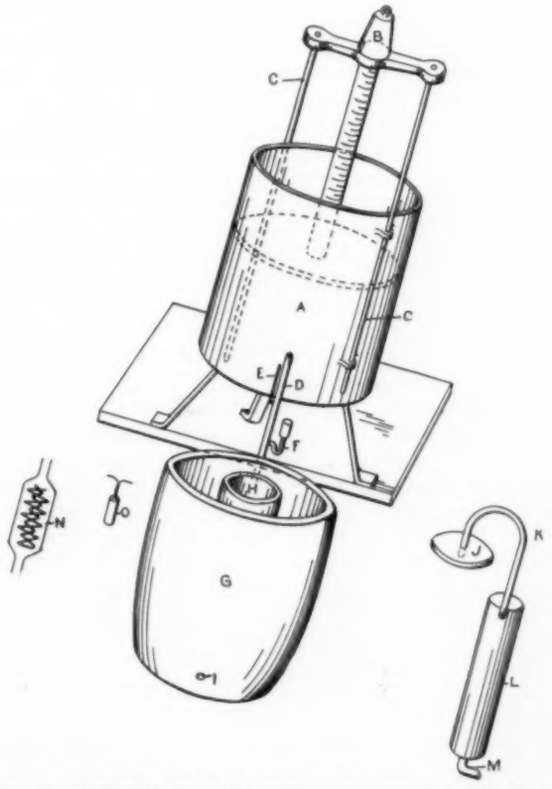


FIG. 1—APPARATUS FOR STUDY OF PYRITIC PROCESSES

[1] This journal, April, 1914, p. 250.
[2] Pyritic Smelting, *Eng. & Min. Jnl.*, Oct. 10, 1903, et. seq.

evolved gases and sublimation products for analysis.

A better arrangement for the inner crucible is shown in Fig. 2, where it is set in a sand-bath held in a metal pan, and is surrounded by a non-conducting cylinder notched at the bottom to slip over the air and tapping pipes. The space between the crucible and cylinder should be filled with mineral wool or other heat insulator. The sand-bath forms a good seal to the space between crucible and cylinder, and it should be heated externally to about the temperature of the gases issuing from the top of the crucible, to overcome the excessive radiation from the small apparatus employed.

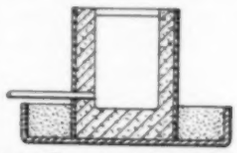


FIG. 2—ARRANGEMENT FOR INNER CRUCIBLE

Fig. 3 shows a better form of air meter, and there should be two of them, with alternate connections; so that while one is being emptied, the other could be filled from an air pump or blower.

Fig. 4 shows an arrangement of crucible for a melting charge, furnishing bullion, matte, or slag, or all of them, by means of which the melted product is removed from in front of the tuyeres. *C* is a lower crucible answering the purpose of a fore-hearth. At the start, it functions as an air chamber on the blast system; as it gradually fills up, the air is expelled. It may be discharged by the bottom plug *H*. The function of the sand-bath *F* and the insulation around the crucible is simply to offset the excessive radiation loss from a small crucible. If its temperature is not above that of the issuing gases, the added heat has no other effect on the charge in the crucible.

Results to Be Obtained from Experiments

With this apparatus, the operation can be made nearly continuous with a dried-out charge, and slagging and matting operations can be carried on, and the behavior of various carbonaceous fuels, charcoal, coke, lignite, and anthracite, can be observed, when added to the charge. With the whole apparatus the effect of blast temperature and of the rate of blowing can be measured with reasonable accuracy, and by analyses of the products at observed intervals, and analyses of the original charge, a control can be had over what has actually taken place in the furnace.

The results of these measurements cannot fail to be of value to metallurgists having to do with desulphurizing, volatilizing, sintering, clinkering, fluxing, slagging, matting or smelting various furnace charges. These results will give some indication of the metallurgical value of various fuels, and will probably determine the lines on which the igneous concentration of zinc from mixed sulphides should be planned and undertaken on a commercial basis.

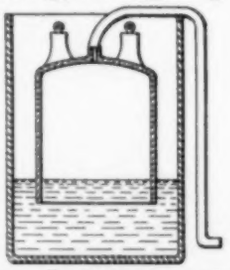


FIG. 3—FORM OF AIR METER

To get the net evolution of heat from the oxidation of a pound of zinc existing as sulphide, deduct the heat of combination of one pound zinc with sulphur, from the sum of the heats of combination of the zinc and sulphur with oxygen. With one pound of zinc there is associated practically one-half pound of sulphur. The burning of this to SO_2 will furnish an additional amount of 1916 B.t.u. evolved in the transformation. To get at the heat evolved per unit of oxygen, divide the heat evolved per unit of zinc by the oxygen required to oxidize zinc, called unity, plus the percentage ratio of oxygen required to oxidize the combined sulphur.

The heat of combination of definite substances is given in text books, as calculated for a different weight of each substance. These different weights are called molecular weights. That is, they are proportional to the weights of two substances which combine to form a compound.

This is a convenient form for metallurgical calculations. The metric system of weights and measures offers great facility in calculation, but because American engineers generally use the pound avoirdupois and the British thermal unit, to express the thermal value of fuels, I have arranged Table 1 in these units.

It should be explained that the figures given in all tables record the amounts of heat given out by the compounds in cooling to somewhat conventional temperatures, which may be either room temperature, or zero Fahrenheit, or zero Centigrade, or absolute zero.

In all metallurgical operations, the heat carried off in the escaping gases is necessarily lost to the furnace. In any particular case we can calculate what heat is thus lost, if we know the composition, weight and temperature of the escaping gases.

This heat they would give up in the calorimeter, if they were cooled to the starting point of the tables.

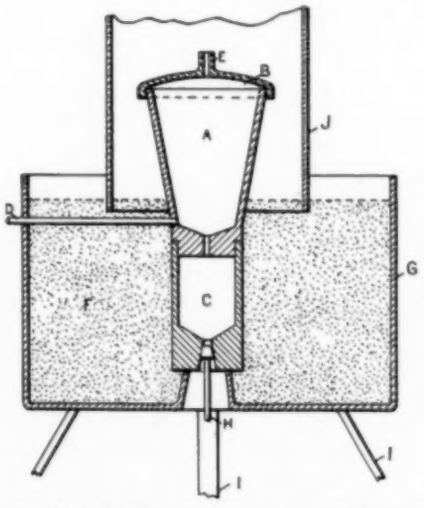


FIG. 4—APPARATUS FOR STUDY OF SMELTING CHARGES

Therefore, this unavoidable loss should be deducted from the values given in the tables, to get at the metallurgical value of any particular fuel. It is impossible to make tables for all temperatures of all gases, but in general the correction to be made in comparing fuel values is slight.

The exception is, where a change of state occurs in one or more of the gases, at a temperature below that at which it escapes from the furnace. This change of state corresponds to the condensation of steam, which gives out a notable amount of heat that is registered in the calorimeter, but is not available in the furnace for the reason that the issuing gases have a temperature above the boiling point of water. It is proper, then, to deduct the latent heat of the water formed from the heat of combustion of carbonaceous fuels. It is well known that these fuels differ greatly in the amount of water formed by their complete combustion. A representative value of the calorific value of commercial coals must, therefore, be arbitrarily chosen.

The calorific value of any substance may be measured for a unit of that substance, or for a unit of oxygen, or of air, required to burn it. A comparison of these measures is often of interest.

In Table 2 I have deducted the heat of combustion

TABLE I

COMBINED WITH		GIVES	AND EVOLVES
One Lb. of	Lb. of	Lb. of	B.T.U.
Zinc	Oxygen 0.246	ZnO 1.246	2,871
Iron	Oxygen 0.286	FeO 1.286	2,111
Copper	Oxygen 0.252	Cu_2O 1.252	1,667
Copper	Oxygen 0.126	CuO 1.126	620
Carbon	Oxygen 1.333	CO 2.333	3,281
Carbon	Oxygen 2.667	CO_2 3.667	14,580
Hydrogen	Oxygen 8.000	H_2O 9.000	52,254
Sulphur	Oxygen 1.000	SO_2 2.000	3,895
Oxygen	Zn 4.062	ZnO 5.062	11,662
Oxygen	Fe 3.500	FeO 4.500	7,381
Oxygen	Cu 3.975	CuO 4.975	6,626
Oxygen	Cu 7.950	Cu_2O 8.950	4,929
Oxygen	C 0.750	CO 1.750	2,460
Oxygen	C 0.375	CO_2 1.375	5,868
Oxygen	S 1	SO_2 2.000	3,895
Oxygen	H 0.125	H_2O 1.125	6,709
Iron	S 0.554	FeS 1.554	771
Zinc	S 0.492	ZnS 1.492	1,191
Copper	S 0.503	CuS 1.503	286
Sulphur	Zn 2.031	ZnS 3.031	2,419
Sulphur	Fe 1.750	FeS 2.750	1,350
Sulphur	Cu 1.988	CuS 2.988	569
Sulphur	Cu 3.975	Cu_2S 4.975	1,142

TABLE II

COMBINED WITH		GIVES	AND EVOLVES	ALSO GIVES	EVOLVES	TOTAL	ABSORBS	NET
One Lb. of	Lb. of	Lb. of	B.T.U.	Lb. of	B.T.U.	B.T.U.	B.T.U.	B.T.U
ZnS	O 0.495	ZnO 0.835	1924	SO_2 0.66	1285	3209	798	2411
FeS	O 0.650	FeO 0.922	1343	SO_2 0.728	1418	2761	491	2270

To burn completely 1 lb. ZnS, requires 0.495 lb. of oxygen for zinc and sulphur, and develops 2411 B.T.U. of available heat.

To burn completely 1 lb. FeS, requires 0.650 lb. of oxygen for iron and sulphur, and develops 2270 B.T.U. of available heat.

To burn 1 lb. of carbon to CO_2 requires 2.667 lb. of oxygen and develops 14,580 B.T.U. of available heat.

To burn 1 lb. of carbon to CO requires 1.324 lb. of oxygen and develops 3281 B.T.U. of available heat.

It then requires about 6 lb. of ZnS to replace 1 lb. of pure carbon burnt to CO_2, but only about 1 1-3 lb. if burnt to CO.

Heat developed per lb. of oxygen for ZnS is $\frac{2411}{0.495} = 4870$ B.T.U.

Heat developed per lb. of oxygen for FeS is $\frac{2270}{0.650} = 3492$ B.T.U.

Heat developed per lb. of oxygen for C to CO_2 is $\frac{14,580}{2.667} = 5467$ B.T.U.

Heat developed per lb. of oxygen for C to CO is $\frac{3281}{1.334} = 2460$ B.T.U.

of a compound, which must be broken up before its components can be separately oxidized. Thus, if both the sulphur and the iron in the compound FeS are to be oxidized, and it takes a certain amount of heat to dissociate the sulphur from the iron, it is only the difference between this amount of heat, and the sum of the heats developed by the oxidation of the separated components that can be utilized. All of the figures given in the table are derived from those given in Dr. J. W. Richards' Metallurgical Calculations, and are referred to the temperature of 15 deg. C. (59 deg. F.) and to normal pressure.

A glance at the tables will show that zinc sulphide compares very favorably with iron sulphide, as a metallurgical fuel, and makes a good showing when compared with partly burned carbon. It is scarcely worth while to spend time and labor in theorizing or in figuring on conditions, which must be imagined.

What is wanted are data, which can be determined only by experiment. It is seldom that the carbon in metallurgical operations is completely burned to carbon dioxide. This indicates the importance of analyzing the gases which escape from the furnace; for a deduction from the calorific value of the carbon must be made for any portion of it which escapes as carbon monoxide. Coal can be credited with only that amount of hydrogen which is not combined with oxygen; for it takes just as much heat to dissociate the water, as the hydrogen thus liberated will produce by burning.

Sulphide of iron is not a common constituent of ores. The bi-sulphide is the common mineral. The second atom of sulphur is distilled off before the smelting zone is reached. It is generally accepted that the sulphur thus freed is no aid to pyritic smelting. Even if it is burned to SO_2 in the furnace, the heat is given out where it is not needed. On the other hand this free sulphur is objectionable: (1) because its expulsion renders latent an unknown amount of heat; (2) because it requires an additional amount of oxygen and consequently of air, to be blown into the furnace.

To furnish 1 lb. of oxygen very nearly 4 1/3 lb. of air are required. An increased weight of issuing gases carries an increased amount of heat out of the furnace for the same temperature of escape. The consequent dilution also lowers the temperature at the focus of the furnace.

From the history of the introduction of pyritic smelting into the metallurgy of copper, it may be safely predicted, that, as a concentration process for the treatment of zinc ores it can only be introduced at some favored locality where a supply of suitable ores is assured; and even then it must await the arrival of the man and of the hour.

Lead sulphide, if present in considerable amount, will add some complications. But the bulk of galena can be removed by simple jigging before concentrating the zinc. If gold and silver are present, they will go mainly into the lead bullion or the matte. The small amounts which go off in the sublimed product can be recovered from the rich zinc sublimate. If no bullion or matte is produced, it will require an analysis of the slag to determine whether it will pay to add it to the charge of a lead furnace.

I have barely touched upon the problems which can be solved in the simple apparatus here shown. There are many other data, pertaining to pyritic smelting in general, which it is very desirable to have in hand.

Denver, Colo.

The Kieselguhr Company of America, Los Angeles, Cal., has issued an interesting booklet on "Sil-O-Cel, Nature's Non-Conductor," describing the uses of kieselguhr products. Sil-O-Cel is now finding application in the insulation of heat in electric furnaces and similar apparatus where the cost of fuel and power is an appreciable item of expense, but only a small part of which is actually consumed in the operation. Among the varied uses of Sil-O-Cel may be mentioned the heat insulation of all sorts of heating appliances, cold storage and refrigerating apparatus; the sound-proofing and fire-proofing of walls, floors and structures. Sil-O-Cel consists almost wholly of silica and is very light in weight.

Rapid Method for the Determination of Chromium in Pig Iron, Cast Iron and Steel

BY H. E. WALTERS

Owing to the general tendency to add alloys or pig iron containing chromium to mixtures for iron castings, it has become necessary for foundries which control their product by chemical analysis to insist on the determination of the amount of this element in the scrap or pig iron used in the mixtures.

The methods given in the text books for the estimation of chromium require too much time for routine determinations and the writer felt that a method of his published some years ago (American Chemical Society Journal, Vol. XXVII, p. 1550 to 1553) could be modified so that a rapid and accurate determination could be made.

Experiment proved this to be the case and the method is used daily.

After working up the method, a search of the literature was made and it was found that a method practically identical was published by M. Phillips (*Stahl und Eisen*, Vol. XXVII, p. 1164 to 1167).

Credit for priority is, of course, due to Phillips, but as the journal used for the publication of his paper is consulted by but a few American chemists the writer feels that a description of the method will be welcome to chemists who are called upon to make this determination.

Method

Weigh two grams of the sample into a No. 3 beaker, add 60 cc dilute sulphuric acid, cover with watch glass and heat until sample is in solution. Add 6 cc nitric acid 1.20 Sp. Gr. to oxidize the iron, and boil about two minutes. Filter into a No. 5 beaker and wash four or five times with hot water, the volume of the solution should then be about 125 cc.

Place over a light, add 5 cc silver nitrate solution and about five grams ammonium persulphate and heat to boiling, the manganese should be oxidized to permanganic acid and this may decompose into manganese dioxide. (If permanganic acid is not formed, more persulphate must be added as the formation of the permanganic acid insures the oxidation of the chromium). Boil about five minutes to destroy excess of persulphate, add 2 cc conc. hydrochloric acid and continue the boiling five to ten minutes to expel chlorine. Cool, dilute to about 400 cc with water, add a measured volume of a standard solution of ferrous ammonium sulphate to reduce the chromic acid, titrate the excess of ferrous iron with a standard potassium permanganate solution.

The number of cubic centimeters of the permanganate solution used subtracted from the number required for the volume of ferrous sulphate added, will give the volume of the permanganate solution equivalent to the chromium.

Reagents and Remarks

Sulphuric Acid—A mixture of one part concentrated acid and five parts of water.

Silver Nitrate.—Four grams of the salt are dissolved in one liter of water.

Ammonium Persulphate.—The salt should be slightly moist.

Permanganate Solution.—The solution is made by dissolving 3.64 grams of pure potassium permanganate in water and diluting to one liter.

Ferrous Sulphate Solution—The solution is made by dissolving 45 grams ferrous ammonium sulphate in water, adding 50 cc conc. sulphuric acid and diluting to one liter.

It is unnecessary to have this solution exactly equal the permanganate solution, as a constant volume is used and the solution loses in strength. It is only necessary to find the volume of permanganate equivalent to the volume of ferrous sulphate used and this should be done every day.

25 cc of this solution will be ample for chromium up to 2 per cent when working on a two gram sample.

The permanganate solution may be standardized by finding the iron value, or by use of a pure chromium salt or sorensens sodium oxalate.

If the solution is standardized against iron the chromium value is found by the equation:

167.52:52.0 :: Iron valuue: X equals chromium value.

If sodium oxalate is used the chromium value is obtained by the following calculations:

Weight of sodium oxalate X .2587 equals weight of chromium. Weight of chromium divided by cc used for sodium oxalate equals value of 1 cc in terms of chromium.

In using the method on high silicon irons a few drops of hydrofluoric acid should be added while the sample is dissolving.

The method will be found very rapid for steels as no filtration is required.

I have encountered no difficulty on account of the presence of chlorides in making the titration with permanganate, and any chance of trouble from this source can be eliminated by adding the titrating mixture used in the determination of iron in the presence of hydrochloric acid.

United Engineering and Foundry Company, Lincoln Foundry Company Dept., Pittsburgh, Pa.

New Buildings for United States Bureau of Mines at Pittsburgh

Plans for the proposed $500,000 experiment station of the United States Bureau of Mines to be located in Pittsburgh, Pa., have been approved by the commission appointed by Congress for that purpose. The Federal Government now owns the property upon which will be erected a group of buildings, especially designed and adapted for the carrying on of the mine-safety work and other investigations in which the Bureau of Mines is interested.

The group consists of three main buildings, the central or mining building, having three stories, flanked by the mechanical and the chemical buildings. In the rear of these and inclosing a court will be the service building.

Between the main group and the power and fuel group will be the entrance to a series of mine shafts. One of these will be used as an elevator to carry heavy material and passengers from the lower level to the upper; another will be for tests of hoisting ropes and similar mining appliances; another will be an entrance to tunnels extending under the buildings and in which mining experiments, such as fighting mine fires, will be conducted.

Congress a year ago, in the public buildings bill, authorized a new home for the Bureau of Mines to cost $500,000. It is now expected that Congress in its present session will make a specific appropriation so that construction work may begin. It is hoped that contracts may be let by July 1. The director is hopeful that the buildings may be completed in the fall of 1915.

Liquid Flow Recorders.—The Yarnall-Waring Co. of Philadelphia, Pa., have just published a list of over 1000 users of the Lea V-Notch recording liquid meters.

Blast Furnace Blowing Apparatus

BY J. E. JOHNSON, JR.

(Concluded from page 242, April issue.)

Steam Valves and Their Settings

The conditions as to the steam valves for blowing engines are no different from what they are in any other type under similar conditions of size, speed, and economy desired. It is therefore obviously unnecessary and undesirable to go into an extensive discussion of this subject here.

In American practice the Corliss valve has won its way to almost exclusive use in high-grade steam engines. The poppet valves, which have given magnificent results in Europe, have never become popular in this country in spite of the economical results which have been obtained with them. It is probable that the conditions of operation are somewhat more exacting with that type of valve on account of its coming against a rigid seat, than they are with the Corliss valve with its rotating motion and absence of sudden stops. At all events the result is as stated, that the Corliss valve gear is preeminent in all the modern blowing engines in service and being built in America at this time.

The original Corliss valve gear was subject to the disadvantage that if the cut-off did not occur at a point somewhat before half stroke it did not occur at all, and steam followed full stroke with utter destruction of economy and terrific stresses on the engine.

With engines on constant mill loads, and particularly before the introduction of the compound which divided the expansion between two cylinders and greatly retarded the point of cut-off in each, this was generally not objectionable, but with the relatively late cut-off necessary for the compound engine, the variable loads to be met, and variations in the steam pressures owing to irregular conditions, so limited a cut-off was not satisfactory for blowing engines, so that for several years makers have been adding an eccentric which enables cut-off to take place under the control of the governor at any point up to about eight-tenths stroke in the high-pressure cylinder, and this constitutes a great advantage under operating conditions, so much so that no engine should be installed for furnace work without it.

Theoretically the low-pressure cylinder does not need the long range cut-off so much, but practically the necessity of operating even though steam pressure be down, and the low-pressure cylinder doing most of the work, makes it very desirable to have this gear on the low-pressure cylinder also, and personally I should not recommend any furnace man to buy a blowing engine not so equipped.

This feature is also of great advantage in starting an engine up from any position in which it may stop without barring it over, and in a heavy engine this is a convenience well worthy of the expense.

The resultant diagrams, Figs. 17, 18, 19 and 20,* indicate certain features as to the stresses in engines which are worthy of attention. It is proper to say that engineers are by no means unanimous on some of these points, and for that reason the views which I shall express are simply my own and are undoubtedly not in accordance with those of some others well qualified to pass on the subject.

There will be seen at the left of Fig. 8 a sharp point extending about 20 lb. per sq. in. below the line of zero pressure at the beginning of the stroke, which runs down to nothing at about 5 per cent of the stroke. This pressure comes from the re-expansion of the air left in the clearance space of the air cylinder, which, of course, is *in the same direction* as the pressure of the steam in the steam cylinder at that time. As soon as the pistons have moved a short distance this air re-expands down to atmospheric pressure, and thereafter the rising pressure in the other end of the air cylinder is increasingly opposed to the steam pressure. It will be seen that if the steam reached full pressure in the steam cylinder at the moment the stroke started, as is customary and proper in power engine practice, there would be practically double pressure on all the reciprocating parts and on the engine frame at this point, at which the velocity of the piston for a given amount of crank travel is very slow, so that this excessive pressure would come at a time to produce the least useful and the most frictional effect.

Inspection of the diagram, Fig. 3, will show that the engine builder has prevented this in part by delaying the admission of live steam so that it does not reach full pressure until after the piston has moved an appreciable distance, by which time the pressure of air in the clearance space is considerably diminished by re-expansion. For this reason the combined net pressure diagram of air and steam cylinders (Figs. 17 and 18) instead of showing a sharp "spike" on the left-hand end of the diagram, as it would if steam were admitted to full pressure at the beginning of the stroke, shows only a considerable "hump." The practice in the case of the low-pressure diagram of the same set (Fig. 5) is even better in this respect, for it will be seen that in this case the piston has traveled the whole distance necessary to permit complete re-expansion of the air before steam reaches full receiver pressure in the cylinder, and if a combined diagram were made for these cylinders the hump at the left, shown in Figs. 18, 19 and 20, would not appear.

Following through this same idea these builders eliminate any compression whatever, both in the high-pressure and low-pressure cylinders. In fact, there is nothing in either diagram to show that the steam first admitted at the beginning of the stroke may not blow through into the exhaust. It is not possible to say from the indicator diagram that it does so, and the care and good judgment of the builders make it unlikely, at the same time so considerable an economy of steam may be effected by very little compression, and with such a slight increase in pressure, that I consider a small amount of compression desirable both for the steam it saves and to make it absolutely certain that live steam does not blow through into the exhaust at the beginning of the stroke.

It will be noted that in this diagram (Fig. 5) and also to a less extent in Fig. 3, the exhaust of the steam is extremely slow. The exhaust valve does not open at all until the end of the stroke is reached, and the steam consequently has little time to leave the cylinder while the engine is turning the center. The result is the sharp "toe" at the exhaust end of the diagram, which in my judgment should come down as shown in dotted lines, very materially increasing the area of the diagram without any ill effect.

Turning now to the Southwark engine cards shown in Fig. 26 we see practice the exact opposite of that of the Tod company in these particulars. The compression pressure rises nearly half way to receiver pressure and admission is so early that full receiver pressure is reached at the very beginning of the stroke.

On the other hand, the exhaust is early, so that full vacuum is reached almost at the very beginning of the exhaust stroke, as it should.

If combined net pressure diagrams were made of this set of air and steam cards there would be found a "spike" of pressure at the beginning of each stroke which would just about double the total pressure on all the running gear and the engine frame for a brief in-

*See April issue for illustrations 1 to 27.

stant of time at which it could deliver no useful work, owing to the low angle of the crank at that position, but in which it could greatly stress all the running gear and the frame of the engine itself and produce excessive wear if not an absolute hammering down of the brasses. Cases are on record in which certain engines of the walking-beam type broke their frames or pedestal caps repeatedly as long as the steam valves were set to give "lead"; that is, to give full pressure of steam at the beginning of the stroke, but which quieted down and ran without further difficulty when admission was delayed to compensate for the re-expansion in the air cylinders.

It will be seen, therefore, that the practice of the William Tod Company and of the Southwark Company is at the two opposite extremes in this respect. The

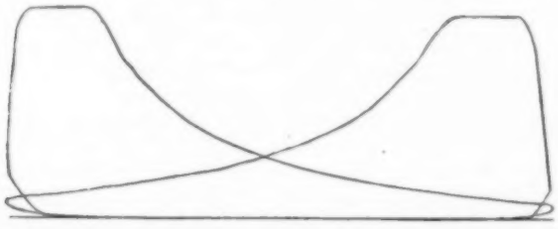


FIG. 28—STEAM CARD TAKEN FROM MESTA LONG CROSS-HEAD BLOWING ENGINE

Tod Company uses no compression and delayed admission, the Southwark uses heavy compression and early admission.

I am able, through the kindness of the Mesta Machine Company of Pittsburgh, to present a pair of cards taken from one of their long cross-head blowing engines which seems to me to embrace the best practice in both respects. There is enough compression to reduce the total steam consumption appreciably, as can be judged by noting the percentage of the stroke still remaining to be made when compression begins; and then delays the admission sufficiently to allow full time for the re-expansion of the air in the clearance space.

In my judgment these cards are illustrative of the practice which should be followed by every blowing engine operator in setting the valves on his blowing engine. It will be noticed that the early closing of the exhaust valve has its complement in the sufficiently early opening of these valves to prevent any loss of area by failure of the steam to exhaust promptly.

In general it may be said that the blowing engine should be indicated at intervals of a few months to prevent or correct the multifarious misadjustments which can arise from many causes, many of which lead to bad economy and others to excessive stresses similar to those I have described and worse.

At plants where the economy of steam is not a prime consideration the hideousness of the steam practice which may prevail and still let the plant operate is beyond belief by those who have not seen it. There is probably no field about the plant where so small an investment of time and trouble will pay so great a return in steam economy and repair expenses avoided.

The Turbo Blower

Within the last ten years the general introduction of the steam turbine and the high efficiency to which it has attained have brought about a great development in centrifugal machinery. It was formerly supposed that centrifugal fans were of no value for pressures above 1 lb. per square inch, and they were seldom or never compounded by putting two fans in series so as to increase the pressure they could attain. Instead, if a pressure of more than a few ounces was desired, the tendency was to pass to the use of the positive pressure blower.

The French engineer Rateau deserves the credit for working out into practical shape the use of the series fan capable of blowing pressures suitable for blast furnaces, and introduced several of these machines in Europe about eight or nine years ago.

Blast pressures in Europe are commonly not so high as those in this country, so these blowers were not suitable for American conditions. Moreover, it has been found to be universally the case that when a prime mover was introduced from Europe into America it had to be redesigned to meet American ideas and American conditions. This has been the case with the turbo blower. The first of these machines in this country was built by the General Electric Company for the Oxford furnace of the Empire Iron & Steel Company, and was started in 1910. A twin machine was started a few months later at the furnace of the Northern Iron Company at Port Henry, N. Y. Probably the largest single installation of these machines to date is that of the Iroquois Iron Company at Chicago, where the sole blowing power for two furnaces consists of three turbos with a capacity of 40,000 cu. ft. per minute each to a pressure of 30 lb.

More recently the Southwark Foundry & Machine Company has introduced the Rateau style of turbine into this country, and has already built several of them.

The Westinghouse Machine Company has as yet built no multistage turbine, but has built some single-stage machines for a pressure of 5 to 7 lb., these not being used in the iron industry, but under similar conditions in other industries.

The theory of the turbo blower is extremely simple. Air is admitted around the shaft, caught by the rapidly revolving vanes, or blades, of the fan, and has imparted to it a high velocity. This velocity is transformed into pressure, and the method by which this may best be done is a subject of some dispute among the designers of this class of machinery. The pressure obtainable in any one stage is limited by the speed which may be attained by the fan, and this is virtually the speed at which it is safe against the influence of centrifugal force.

The discharge from one fan is lead around through an annular port in the casing to the center of the next fan, which increases its pressure by a similar amount, and then to a third, and so on.

The number of stages to be used is not definitely settled. The Rateau blowers use eight, the first General Electric blower used six, but in the more recent types of construction the latter company have diminished the number of fans in series to three by increasing the speed.

The pressure increases more rapidly in the later stages than in the earlier ones because the density is increased by the increasing pressure.

The work put upon the air in compressing it heats it exactly as it does in a piston-blowing engine, but to a greater extent because the efficiency of the operation is lower with greater losses of energy in eddy currents, etc., which are eventually converted back into heat. The casings are therefore cored out hollow and cooled by water circulation to keep down the temperature of the air.

THE SOUTHWARK TURBO BLOWER

The internal construction of the Rateau machine as built by the Southwark Company is shown in Fig. 29. The U-shaped discharge passages by which the air discharged from one fan is delivered into the central aperture of the next are clearly shown. In this turbine there are fans or impellers in two groups of four each,

the inlet of the first group being next to the central bearing between the two sets. The air then progresses to the left and is discharged into a receiver pipe which carries it over into the inlet of the second group next to the inside bearing, and it then progresses outwardly through this group to the discharge at its right-hand

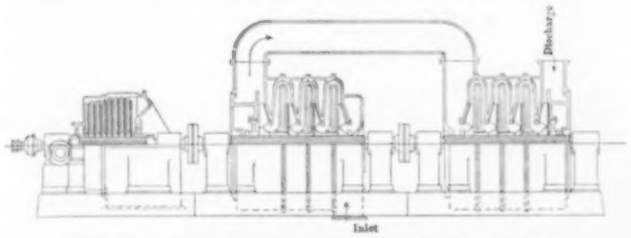


FIG. 29—SOUTHWARK RATEAU TURBO BLOWER

end. In this way the end thrusts against the two sets of impellers are balanced against one another so as to throw as little work as possible on the thrust bearing.

The turbine which drives the blower is shown in half section at the extreme left. The shafts for the turbine, and the two sections of the blower are all separate, and coupled together by flange couplings to permit an absolute alignment of each shaft in its own bearings. The shaft is located endwise by a thrust bearing at the left-

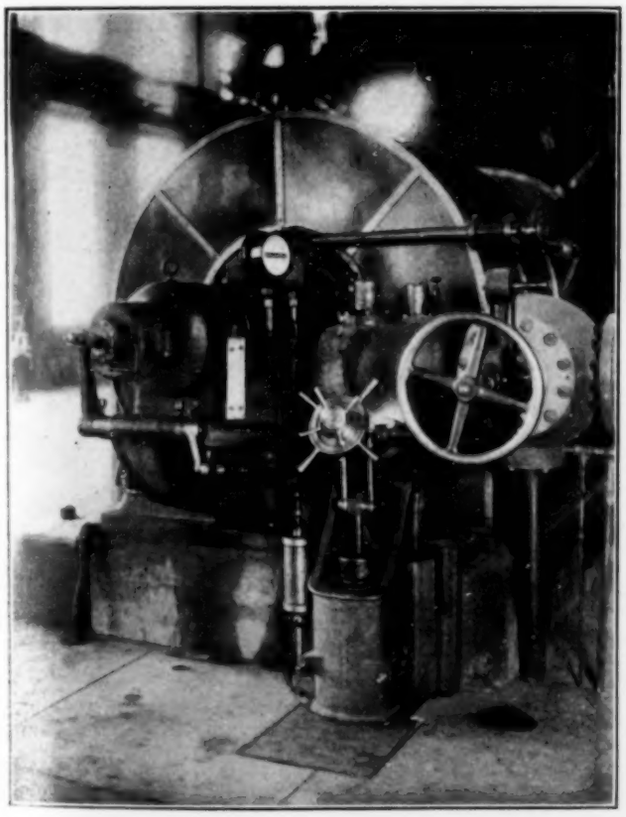


FIG. 30—STEAM END GOVERNING APPARATUS AND THRUST BEARING ADJUSTMENT, RATEAU TURBO BLOWER

hand end of the turbine shown in Fig. 30. This thrust bearing is capable of being moved and can be adjusted by a hand-wheel and screw to secure proper clearance and operation. The general arrangement of this machine is well shown by Figs. 31 and 32.

The details of the design of the impeller, casings, etc., are highly technical matters in which mathematical theory and elaborate experimentation must go hand in hand to get the best results. To the great majority of users the only question of importance is how much steam is required to deliver a given quantity of blast at a certain pressure, and the details of the methods by which the guaranteed results are obtained is a matter of indifference to them and I make no attempt to treat of these matters, because it seems to me outside the field of the present work.

The turbo blower is of course entirely valveless, and it therefore escapes the troubles of valve design and operation which I have briefly described in connection with reciprocating engines. It is also entirely without anything comparable to the piston displacement of the reciprocating blowing engine. That is, it has no metering effect, and its speed is accordingly no gage what-

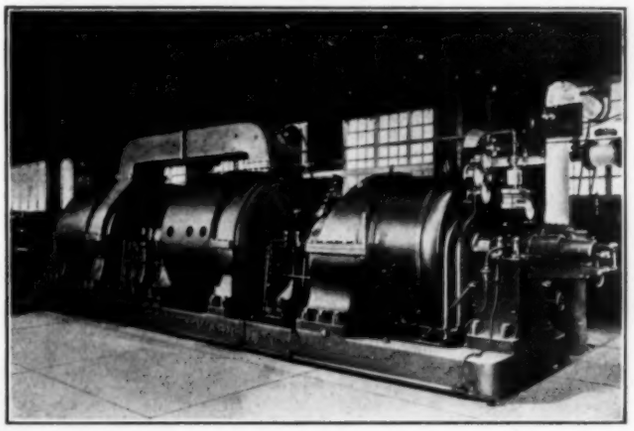


FIG. 31—SOUTHWARK RATEAU TURBO BLOWER

ever of the quantity of wind it is delivering under given conditions. It is the function of a blower or centrifugal pumping apparatus of any kind to produce pressure and the flow which results is proportional to the difference maintained between the pressure at the discharge of the apparatus and the pressure in the vessel into which it discharges. If a reciprocating blowing engine, running at a certain speed, delivered the desired amount of air to a furnace at say 15 lb. pressure, and if the resistance of the stock in the blast furnace suddenly fell so as to let the pressure drop down to 14 lb., it would make little or no difference in the quantity of wind delivered by the engine, but with the turbo blower it would make an enormous difference, because it would endeavor to maintain the same discharge pressure, and with the pressure difference between this and the resistance of the furnace increased by the drop in the latter, the flow would be greatly augmented. For

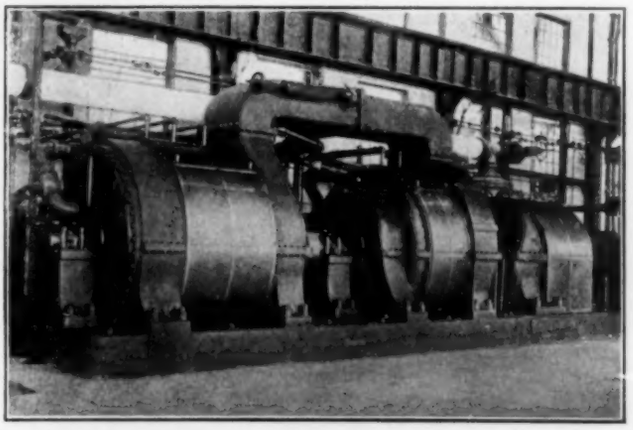


FIG. 32—SOUTHWARK RATEAU TURBO BLOWER

this reason the turbo blower requires a governing device which shall control the quantity of air passing through it.

In the Rateau system the well-known principle of the

Venturi meter is used. In this an inlet pipe is provided which has a relatively small throat approached by a gradual taper and followed by an expanding taper to the normal diameter of the pipe. The difference in the velocity of the air at this throat and in the large area behind it, gives rise to a difference in pressure at these

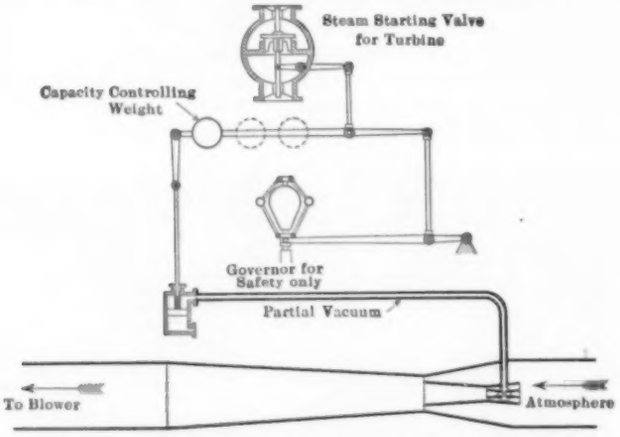


FIG. 33—METHOD OF CONTROLLING CAPACITY OF RATEAU TURBO BLOWERS—SOUTHWARK FOUNDRY & MACHINE COMPANY, PHILADELPHIA, PA.

points which depends upon the velocity of the flow, and by measuring the pressure with a differential gage the flow can be accurately calculated and controlled. The arrangement is shown diagrammatically by Fig. 33. The partial vacuum at the throat of the Venturi meter is maintained constant by means of a relay working on the steam governor of the turbine. If the flow increases the vacuum in the throat of the Venturi tube increases, and this acting through the relay cylinder operates on the steam valve of the turbine and reduces its speed, which in turn reduces the difference in pressure maintained by the blower, until the quantity of air flowing through it is reduced to the amount desired. A centrifugal governor is interconnected with the same system so as to close the steam valve entirely in case of excessive speed.

THE GENERAL ELECTRIC BLOWER

The principle of this blower is the same as that of the Rateau, but the number of impellers used is smaller, and the whole of the blower is built in one body, without the feature of balancing by having the flow from the two half sections of the impeller in opposite directions. This produces a shorter and more compact machine. This blower is shown by Figs. 34, 35, 36, 37 and 38, taken from a paper on the "Turbo Blower" presented by Mr. Richard H. Rice, of the General Electric Company, before the American Institute of Mining Engineers, and published in their Bulletin for May, 1914.

The governing device of this machine is on a somewhat different principle from that of the Rateau; it is shown by Fig. 34. The inlet pipe ends in a large inverted cone in which a circular diaphragm is suspended from a beam overhead. It is obvious that the area of the annular space between the diaphragm and the walls of the cone will vary with the location vertically of the diaphragm, and that the flow of the incoming air up past this diaphragm will have a tendency to lift the latter varying with the velocity of the air through the annular space, and the governing is done by the varying lift of this diaphragm. Thus while a different mechanism is used it produces about the same resultts as the Venturi tube.

If the pressure required by the furnace increases so as to decrease the flow of air under the speed at which the turbine is running, the diaphragm promptly drops down carrying with it the beam which operates on the steam valves, admits more steam and increases the speed of the turbine until the flow of air is restored to the normal. In this turbine also a centrifugal governor is provided to prevent excessive increase in speed.

The advantages of the turbo-blower are its small size, its entire freedom from reciprocating parts, and consequent ability to dispense with any but a light foundation, the small number of moving parts, *there being in effect but one*, and its ability to dispense with lubricating oil both in the steam and air ends. Great advantages are claimed for it also in the absolute steadiness of the blast which it produces, and the freedom from pulsation which results from a continuous discharge.

In the paper by Mr. Rice above mentioned he describes researches which prove the absence of such vibrations with the turbo blower, and their presence with reciprocating blowing engines, but whether this absence may be translated into dollars and cents of advantages in operation is a matter concerning which no proof has as yet been offered and concerning which I confess a considerable degree of skepticism.

It is claimed without hesitation that these blowers on account of the steadiness of their action, etc., enable a furnace to produce less flue dust and to make iron with less fuel than can be done with any other type of blowing machinery, but no definite data on this subject have been offered to support this contention, which also seems to me doubtful.

Fine points of this kind are always exceedingly difficult to prove in an operation of such magnitude as the

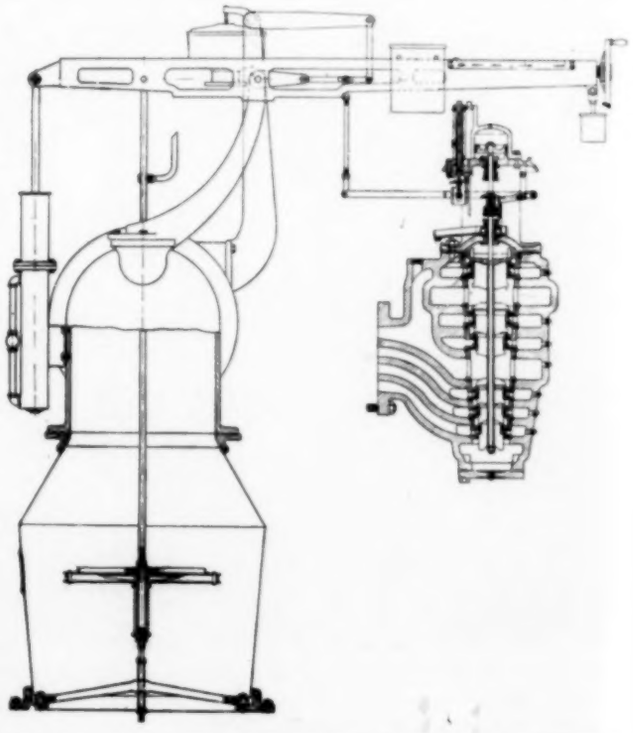


FIG. 34—CONSTANT VOLUME GOVERNOR FOR CENTRIFUGAL COMPRESSORS

blast furnace, and the situation is complicated by the fact that the turbines have in the nature of things, in many places at least, replaced obsolete blowing engines installed under bad conditions and therefore likely to be drawing steam into their inlet and discharging it into the furnace along with the air, with consequent detriment to fuel economy. Moreover, these engines being

old and uneconomical, and being presumably of the low-speed variety, they gave greater pulsation to the blast than more modern and higher speed engines. It is therefore extremely doubtful whether the mere fact that certain advantages are found where the turbo blower is used, which were not found before its introduction, is due solely to the type of blower introduced, or whether they would not have been obtained equally well with any other type of good modern blower.

Much is claimed also for the accuracy of calibration of the air-measuring apparatus of these machines, and in a paper by Mr. S. G. Valentine, read at the February, 1914, meeting of the American Institute of Mining Engineers, and published in the *Transactions* for that year, he gives the results of his experience in the use of one of these blowers on a furnace which bear upon this point. Among other data he states that only 41 cu. ft. of air were required to burn a pound of coke based on the calibration of the air-measuring apparatus of the turbo blower. We shall subsequently see that about 63 ft. are required theoretically for this purpose without any loss by leakage, not only in the engine but around the stoves, the tuyere and elsewhere, and if only 41 ft. are used then one-third of all the fuel charged is being dissolved by direct deduction in the upper regions of the furnace and never reaches the tuyeres at all.

This hypothesis does not agree with the relative low fuel consumption reported by Mr. Valentine of about 2150 lb. of coke on an ore mixture consisting largely of magnetite which required a large amount of heat in

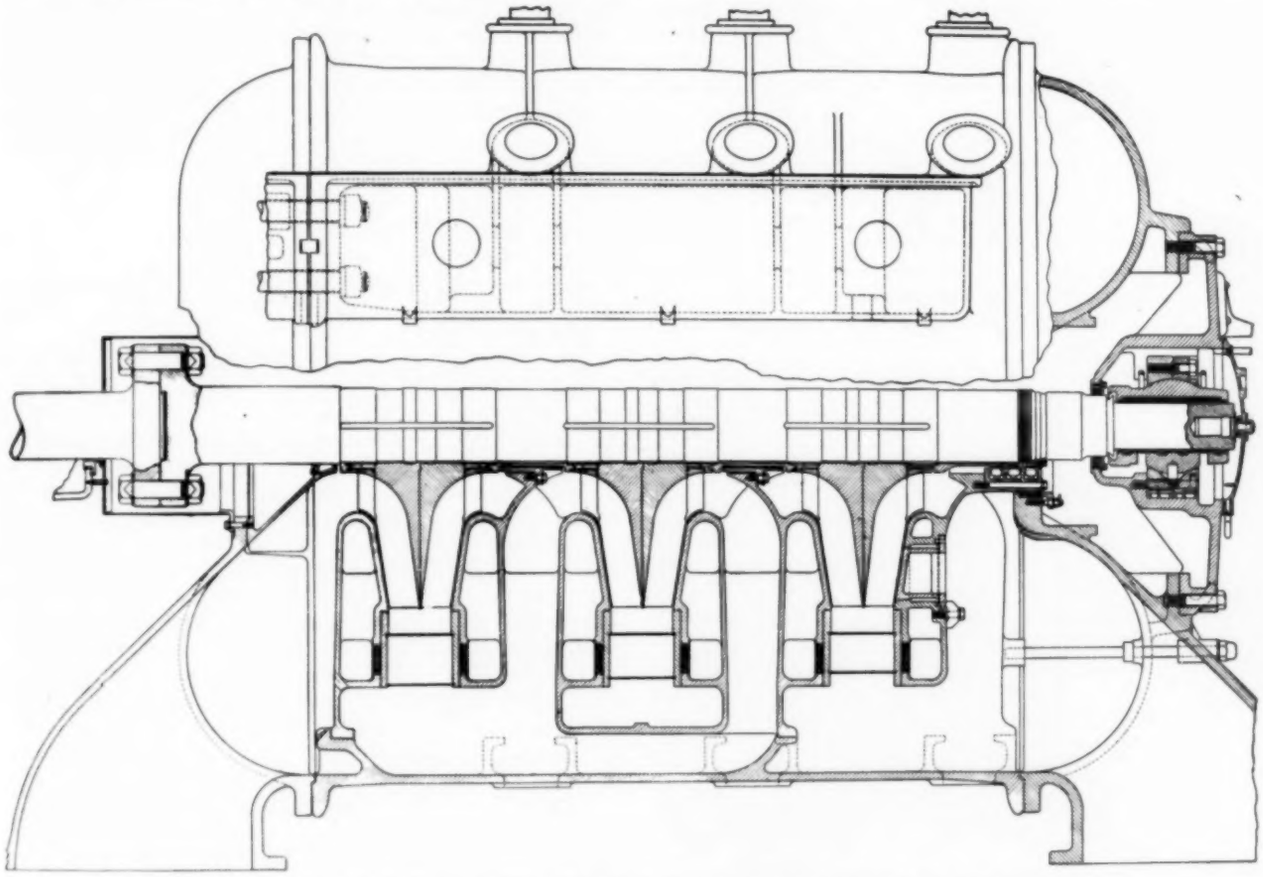


FIG. 35—THREE-STAGE GENERAL ELECTRIC TURBO BLOWER PARTLY IN SECTIONS

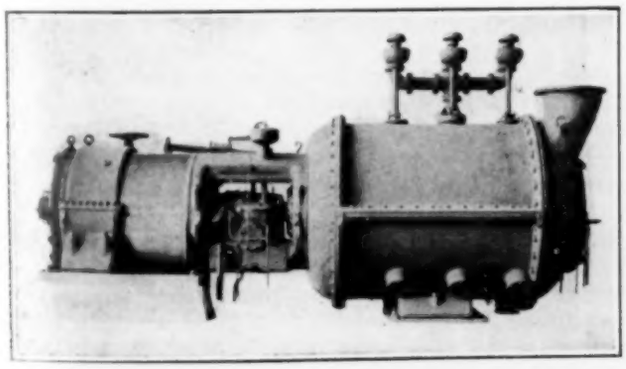


FIG. 36—CENTRIFUGAL COMPRESSOR RATED TYPE T—3—25,000—15/30—3000/3800 DRIVEN BY A 2000/3400 CONDENSING CURTIS STEAM TURBINE

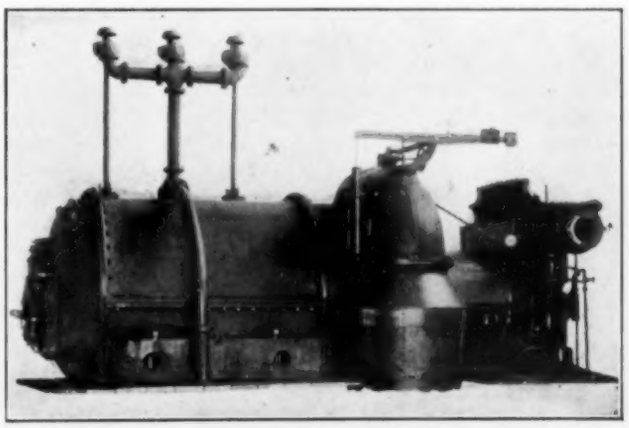


FIG. 37—TYPE T—3—35,000—15/30—2500/3250 F CENTRIFUGAL COMPRESSOR DIRECT CONNECTED TO 2900-H.P. CURTIS STEAM TURBINE

the hearth, and, in fact, Mr. Valentine admits that his figures, based on the analysis of the top gases and carbon burned, differ from the calibration figures of the turbo blower by about 10 per cent.

I have information concerning practice in which the solution loss is likely to be much higher than it is in Mr. Valentine's practice, and in spite of this the actual quantity of wind per pound of coke figured from the analysis of the top gases and the actual coke burned at a number of furnaces for a long period of time was over 51 cu. ft., or more than 25 per cent in excess of that shown by Mr. Valentine's figures.

I have recently been advised by Prof. J. W. Richards, of Lehigh University, that he has gone over the data given by Mr. Valentine by two different methods and that both show clearly that the actual air delivered by this turbo blower must have been 15 per cent greater than the calibration of the machine indicated, and making this correction it would seem that the correct

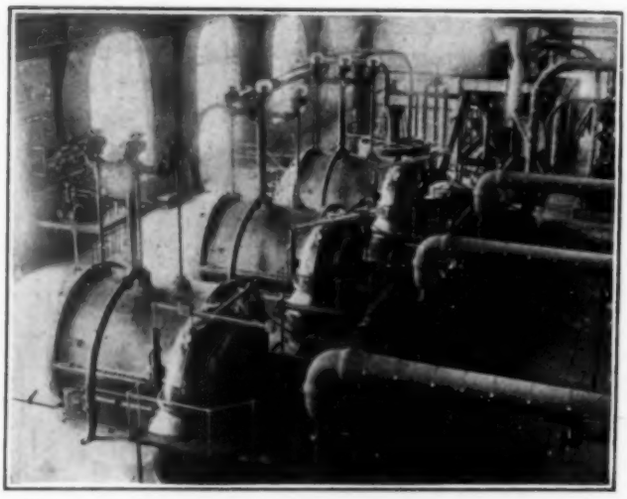


FIG. 38—THREE TYPE T—3—40,000—15/30—2500/3250 R.P.M. FAIR COMPRESSORS DRIVEN BY 2900/5200-H.P. CURTIS STEAM TURBINES INSTALLED AT IROQUOIS IRON COMPANY, CHICAGO, ILL., FOR BLOWING 500-TON BLAST FURNACES

displacement of the turbo only corresponds to about 3 per cent more air delivered than the piston displacement of the antiquated engines it replaced. This is probably not altogether correct but it does seem to be established by these data that the calibration of this turbo is decidedly incorrect and that any claims made for superior economy based on these results are a structure on a foundation of sand which will not fare well at the hands of discriminating criticism.

Considering the extremely elusive nature of air and the possibility of error in measurements of its velocity, due to the fact that this velocity at points quite close together may vary very widely, I am led to the conclusion that the calibration of these machines is not yet on a basis of such complete reliability as their manufacturers seem to believe.

The subject as a whole is a new one, and the number of those who have had an opportunity to handle turbo blowers is very limited, the writer not being among the number. It is therefore not possible at this time to say the last word on this or many other details of this subject.

The Disadvantages of the Turbo Blower

I. PULSATION OF DISCHARGE

Under certain conditions of operation at considerably less than the rated capacity of these machines, they are liable to a very disagreeable pulsation of the discharge, the theory of which I do not completely understand, though I believe it has been worked out mathematically. It seems to be due, however, to the fact that the volume is too small to maintain the delivery velocity necessary to overcome the pressure over the whole area of discharge, continuously, and the discharge therefore breaks and a backflow from the discharge pipe into the turbine casing takes place at short intervals, producing this pulsation. It is claimed to be overcome in the later types of these engines by the introduction of a butterfly throttle valve in the inlet pipe above the diaphragh.

II. INEFFICIENCY

The efficiency claimed for these machines by their builders under best conditions is 70 per cent, and of course this falls off on both sides of the maximum along the characteristic curve of practically all centrifugal pumping machinery.

The diagram factor of the air card from a well-designed blowing engine as a whole is about 95 per cent, and the mechanical efficiency of the engine as a whole, as I have previously stated, should be about 92 per cent. By diagram factor is meant the ratio of the actual diagram produced by a given engine under a given discharge of pressure to the theoretical indicator card with an adiabatic compression for the same pressure. The product of these two is about 87½ per cent, the difference between this and 70, or 25 per cent, is the handicap which the turbo blower must overcome to equal the performance of the reciprocating blowing engine.

Turbines have been brought to a very high state of perfection, particularly in very large units, such as are used in electric generating stations. But it may reasonably be doubted whether a turbine of, say, 3000 hp, with an efficiency of 70 per cent in the blower end, which would deliver 2100 air-hp, can do 25 per cent better in steam consumption than a steam engine properly designed and running with the conditions of boiler pressure, superheat, and vacuum, which are admittedly indispensable to the economy of the turbine.

If it be impossible for the turbine to do 25 per cent better than the reciprocating engine under these conditions than obviously the superior efficiency of the turbine will not offset the low efficiency of the blowing end, and the turbo blower as a whole will be a less economical unit than the reciprocating steam engine.

The steam expert of one large and extremely well-managed company has publicly expressed a doubt as to whether the turbo blower could get along with as little steam as the reciprocating engine, his company having both reciprocating engines and a turbo blower in the same building and operating under identically the same conditions.

III. FAILURES

There have been several wrecks of turbo blowers in this country, but these apparently have been due to defects in the design of new and larger units than had before been attempted, rather than to any inherent defect in the principles involved. This we have long since learned is the price which must be paid in the development of new equipment, and must therefore not militate unduly against the turbo. At the same time, it cannot be denied that turbines in other service have more than once "gone through themselves," to use the expressive phrase of the operator, with consequences so disastrous as to leave little of the structure of any value, even for repair purposes. Before the turbo blower can establish the supremacy towards which its builders are casting their eyes, it must establish a high degree of immunity from accidents, and also an economy not only eclipsing that of the best reciprocating

steam engines, but rivaling that of the gas engine, which increasingly, as time goes on, must become a powerful competitor in blowing machinery.

The Condenser

The auxiliaries of the steam plant at a blast furnace do not differ from those of any other steam plant of similar size and character, and for that reason it is not necessary to discuss most of them here, but the condenser is important enough to deserve some attention.

These for steam engines are of two types, the direct

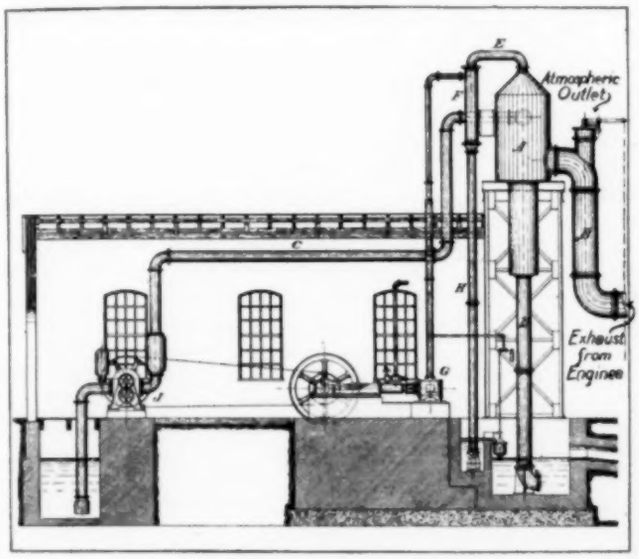


FIG. 39—WEISS CONDENSER

contact or jet condenser, and the surface condenser. Surface condensers are high in first cost and having an enormous number of packed joints are difficult of maintenance for continuous operation. Moreover, the water available at blast furnaces is not always of such character as to enable them to be kept as clean as they should be for best results, and when foul they soon lose their efficiency and the vacuum drops. For this reason when reciprocating blowing engines are used the elevated syphon condenser, working on the counter-current principle, and with positive means for removing the air, is very generally preferred.

The first of these brought into use was the Weiss, introduced by the Southwark Machine Company, shown by Fig. 39. This is of the elevated type with a vertical tail pipe about 35 ft. long, long enough, in other words, to carry out the condensing water and water of condensation without pumping, against any vacuum which the condenser may produce. The air is taken off from the condenser by a dry-air pump, *G* in the illustration, the condenser being designed to discharge the air after it has received the maximum cooling possible, so as to make its density at this low pressure as high as possible and enable the air pump to handle it to the best advantage. The air pump engine drives by belt or gear drive a rotary pump, known as the Bibus pump, which supplies the water for the condenser. The Bibus pump is used on account of its high efficiency, but owing to its gearing, etc., this pump is not as well adapted to run submerged as is a plain centrifugal pump, and as condenser pumps in the nature of things are extremely likely to be submerged from time to time, I personally prefer the simpler if somewhat less efficient centrifugal machine which can run submerged indefinitely.

Several condensers of the same general style as the Weiss are now on the market, of which one of the best and most favorably known is the Helander, designed by Mr. A. H. Helander, formerly chief engineer of the Mesta Machine Company, now vice-president of the William Tod Company, of which a photograph is shown in Fig. 40. This condenser dispenses with the supporting tower used by the Weiss, the tail pipe of the condenser itself being made strong and stiff enough to support it. The air is taken off at the high point of the condenser body, as in the Weiss, different types of apparatus being used to pump it out.

In some installations a steam jet or modified exhauster has been used whose steam economy is not very much lower than that of a mechanical pump, and which is low in first cost, and completely eliminates moving parts. In other cases a crank and flywheel vacuum pump is used as in the Weiss. Water is generally supplied by a centrifugal pump driven either by a motor or by a small direct-connected steam turbine.

In blowing engine plants one condenser is generally installed for several engines, and this system has much to commend it, at the same time if steam for many units is to be condensed, the distance through which the exhaust has to be carried to the condenser becomes great and the piping large and expensive, while the vacuum realized on the further engine is probably never as good by an appreciable amount as in the nearer engines, so that this system must not be carried to extremes, especially as the high cost of the exhaust piping in a large installation would go far to pay for additional condensers. Neither must it be forgotten that several units of this kind have the advantage of greater flexibility and more freedom from general interruption than a single large unit.

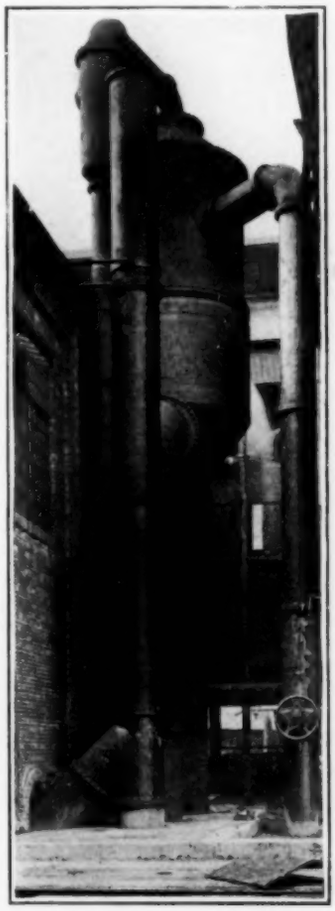


FIG. 40—MESTA HELANDER BAROMETRIC CONDENSER

For turbines the barometric condenser is sometimes used but to get the best results these machines require vacua which measured as absolute pressures are only from a half to a third of those used with steam engines, therefore it is highly desirable to have the exhaust connection extremely short and very large, so as to avoid both friction losses and leaks. For these reasons the condenser for the turbine is in the best practice placed immediately beneath it and in some cases forms the base upon which the turbine rests. For this service either some sort of jet condenser with water discharge as well as dry-air pumps, or a surface condenser is used. The latter is particularly desirable with turbines for the reason that their exhaust contains no oil and may be used for boiler feed without treatment, and for the high vacua desired in this service they have the advantage of not introducing any air dissolved in the condensing water, which is an important factor under these conditions.

As a result of these considerations new types of jet

condensers have been invented and new designs of surface condensers brought out so that condensers as a whole have received a vast development in recent years. In relation to blowing power for furnaces, however, these conditions are not sufficiently important to justify more extensive treatment here.

Combination of Turbine and Reciprocating Engine

There is an application of the turbo blower to blowing engines of which no actual installation has as yet been made, but the possibilities of which have been figured

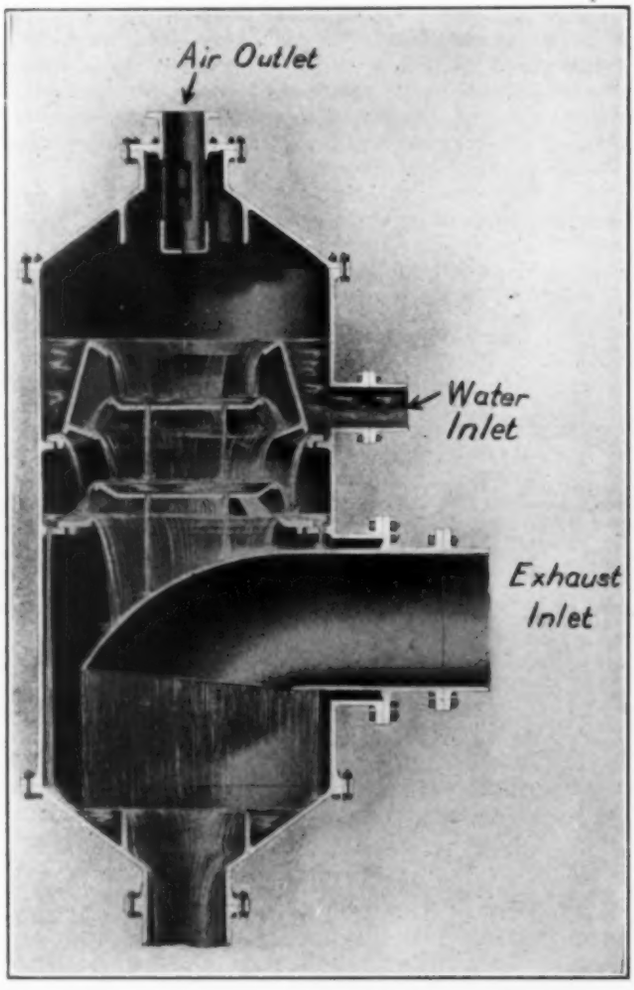


FIG. 41—VERTICAL CROSS-SECTION OF HELANDER CONDENSER VESSEL

out on the basis of actual practice, and specifications prepared for such an installation. One is likely to be made before this work appears in print.

This is a combination of the turbo blower driven by a low-pressure turbine, with existing blowing engines. The turbo blower is not designed to blow the full pressure required for the furnace, but only to do about one-half the work of compression, supplying the air under this partial pressure to the air cylinders on the existing blowing engines.

The advantage of this combination is that the turbine is a more efficient motor for pressures below atmospheric than the steam engine, particularly where high vacua are obtainable, and the turbo blower, while not more economical for low pressure than a good piston blower, is relatively more economical for low pressures of 6 or 7 lb. than it is for pressures of 15 lb. and upward, not because the turbo itself has a higher efficiency at the lower pressures, but because the friction of the large cylinders required for reciprocating blowers, unless they are most carefully designed, reduces the mechanical efficiency of that type of machine at low pressures, so that it is doubtful whether they are as economical below 6 lb. as are rotary blowers or perhaps turbo blowers, therefore the rotary unit as a whole is more economical for very low pressures than a reciprocating one. It is also much lower in first cost, and by combining the two types of machines and using each for the range of pressures for which it is best adapted, we obtain the highest efficiency with the lowest first cost. This is particularly true where existing installations are either uneconomical, unable to blow the pressure required, or unable to furnish the volume required.

By putting a turbine and condenser on the exhaust of a non-condensing engine we can recover a horsepower for about 30 to 35 lb. of steam, depending on the vacuum available. This power applied to a turbo will compress the quantity of air required to a pressure in ordinary cases of 5 to 7 lb. This increases the density of the air and therefore increases the capacity of the air cylinders of the reciprocating engines, and also obviously raises the pressure to which they can compress the air by at least the amount of this precompression.

The turbo blower will compress air to a pressure of $6\frac{1}{2}$ or 7 lb. in a single stage; therefore, in ordinary cases only a single-stage unit will be required in applications under this system.

Both the reciprocating engine and the turbo blower labor under certain disadvantages when used singly which are eliminated when they are used in combination, thus the turbo blower alone must have stages enough to blow the maximum power required, for instance, 30 lb., even though 15 only will be required 99 per cent of the time. Similarly the air cylinder of the reciprocating engine must be large enough for the maximum volume of air to be handled, even though this be required only occasionally. The turbo blower, on the other hand, can supply any increase in quantity of air desired within reason, without any change in its construction, while the blowing engine can compress to any pressure within reason without any change in its construction.

By combining these two units we obtain the volume capacity of the one and the pressure capacity of the other without the need of excessive size in one case, or multiple stages in the other. This arrangement has also the great advantage of retaining the metering effect of the piston of reciprocating engines, which is certainly more positive than the systems of volume governing so far applied to the turbo blower.

In the combined unit the question of governing the turbo practically takes care of itself, since the quantity of steam exhausted by the reciprocating engine controls the speed of the turbo, and this steam must depend upon the volume of air blown and the pressure to which it is raised. If the blast pressure required increases the tendency of the reciprocating engine is to slow down slightly and so slightly to decrease its discharge while the increased quantity of steam which it exhausts tends to increase the speed of the turbine and so to increase the pressure at which the turbo blower discharges, thus making up by an increase in density for any decrease in displacement of the reciprocating engine.

In the actual case for which specifications were prepared, there were three standard long cross-head blowing engines, two with good steam cylinders, the other with a poor steam cylinder, all non-condensing. The owners had obtained bids on a single low-pressure unit to take the exhaust from one of these engines and run condensing, letting one of the high-pressure engines

run condensing with the other standing as a spare.

It was easy to show that on the basis of the guaranteed figures of the turbo blower manufacturers a single turbo blower could be installed which would supply the two good existing high-pressure engines with air compressed to 6½ lb., and this increase in density, with a slight and entirely permissible increase in speed, would have made the weight of air discharged by these engines the same as that now discharged by all three. The exhaust from both of these would have gone into the low-pressure turbine, and from that into the condenser, and would have been sufficient with any ordinary vacuum to drive the turbo blower at a speed which would enable it to supply precompressed air to both reciprocating engines. The third engine would have stood as a spare. The air cylinder heads of the blowing engines would have required to be closed in so that they could receive this air under pressure. A large inward-opening check was to be provided in the pipe carrying the precompressed air so that if anything happened to the turbo blower it could instantly be shut down and the reciprocating engines would then get their air supply from the atmosphere. This would have given the furnace two-thirds wind until the third engine could be started up, which would be only a matter of a few minutes. Finally it was shown that this equipment could be installed complete for a considerably smaller sum than would be required for the low-pressure unit, and that its steam consumption would be smaller than that on the other plan by several thousand pounds per hour.

This possible installation is set forth here because of the advantages which I believe it to have for such cases. It may also be said that the installation above described, while not installed as yet, was not rejected by the owners on account of any defect in the system, but only because they decided not to install additional blowing power at that time.

The Gas-Driven Blowing Engine

It is now more than half a century ago that Otto first built internal combustion engines using the four-stroke cycle, and the economy of these engines was early recognized as being far superior to that of the steam engine in thermal units required. Before the days of the universal use of gasoline, gas was the only fuel used in such engines, and the difficulty of making suitable producer gas for them stood in the way of their earlier introduction.

In the case, however, of blowing engines for blast furnaces, which are in one sense only gigantic gas producers, the advantages of using the gas they supply directly in the engine cylinders are obvious. The first suggestion to carry out this plan was made in 1876 by Mr. Frank Firmstone, then manager of the Glendon Iron Works, to Mr. P. L. Weimer, of Lebanon, an engine builder of some note, but nothing was done in the way of carrying it out for nearly twenty years, when in 1895 Mr. B. H. Thwaites in England installed a small gas engine and operated it continuously for a considerable period on blast-furnace gas.

The idea was then taken up by German and Belgian engineers and to them is due the credit for overcoming the enormous technical, mechanical and financial difficulties involved in carying this simple scheme into successful practice.

It was only after engines of this type had reached a high state of development in Europe that they were introduced into this country, a circumstance which has caused much shame to some good Americans, but I believe does not reflect as much discredit upon this country as has frequently been claimed, on account of differences in conditions unnoticed by casual observers.

These differences are financial and industrial rather than technical, and consist in the fact that in Europe capital can earn only a relatively small rate of interest and labor only a small rate of wages compared with what both command in this country, while raw materials are scarce and dear in Europe and have in the past been ridiculously cheap in this country, particularly coal.

The saving to be made must be bought, as we shall presently see, at the price of enormous expenditures in capital and in high-priced skilled labor, while its value could only be measured in terms of the saving in coal, one of our cheapest commodities.

When these technical savings were reduced by the amount of the high labor cost required to make them, the interest which the balance would pay on the capital involved was often less than could be earned by that capital in addition to the producing capacity of the plant otherwise.

It is true that this view of the subject involves the use of coal which might be saved for future generations by the other system, but this is a subject to follow which would take us far beyond the proper boundaries of this work and I shall not attempt to analyze it further than to suggest that, admitting the value of the "conservation" idea, it is proper to ask whether the saving of money, which represents value already created, may not be as justifiable as the saving of raw material which only has potential value.

Or to put the matter in different form, if the owner of a plant can make more interest on the capital invested by using more raw material than is theoretically necessary, who is to compensate him for the loss he makes by following the opposite course?

On the other hand, this policy is capable of great abuse, and Americans, as a nation, have had in the past and to some extent have even yet a tendency to prodigality and to ignore savings of various kinds which they might make, more through mental inertia than through any more worthy motive.

It may be admitted that the policy of conserving capital at the expense of raw material has often been carried too far, and the gas engine may be such a case. I shall give at the end of this chapter an outline of the method by which this question may be settled on its merits in each individual case.

The conditions to be met, and the difficulties to be overcome in making the gas-blowing engine a success may be briefly stated as follows:

First: Blast-furnace gas as it comes from the furnace contains a vast quantity of fine and exceedingly abrasive dust which must be completely removed before it is introduced in the cylinders of the engine or the latter will soon be destroyed by wear.

Second: The gas engine is a prime mover with little or no overload capacity, and with an efficiency which diminishes very rapidly as its load drops off. This is the opposite to the condition in the case of the steam engine, which has a very large overload capacity, and which maintains its economy well at loads very much smaller as well as much larger than its rated load. Therefore, when the blast pressure required by the furnace changes, the steam engine has no difficulty whatever in accommodating itself to the change, but the gas engine must either work at the disadvantage of an uneconomical light load normally, in order to be able to carry the heavier pressures when they arise, or else it must have special devices to enable it to compress less air when a high pressure is required, at the same time maintaining its speed and power.

Third: The gas engine when it began to be developed for use for blast-furnace gas was very largely a single-cylinder, single-acting engine, which, with the

four-stroke cycle, meant that it received but one working stroke in two revolutions. The reason for this limitation was that it was considered almost impossible to operate piston rods with their accompanying glands at the high pressures and high temperatures involved in this type of engine.

Fourth: Owing to the intermittent and rather complex nature of their cycle these engines were in the early days freakish, unreliable, uncertain and difficult to operate to a degree which in the opinion of many American engineers debarred them from use.

Fifth: Owing to the operating difficulties just mentioned, and to the high repairs which went with them, the operating and maintenance cost was very high.

Sixth: The first cost of these engines, both for the engine proper, for foundation and for house, was and is even yet enormous, and as this first cost must be amortized at a relatively heavy rate on account of the rapid obsolescence, and somewhat rapid deterioration of these engines, the fixed charges on them were very high.

Coming now to the solution of these problems and difficulties, the result desired has been achieved in each case by the same formula. A vast amount of technical work of the highest order, the endurance of a vast number of operating difficulties which resulted in deficient blast supply for the furnaces at frequent intervals of uncertain duration, and made the managers regret the day that the gas engine was born, but which led eventually to methods whereby these difficulties might be avoided or overcome, an enormous number of experiments, many of which in the nature of things were unsuccessful, and the expenditure of great sums of money for development.

THE CLEANING OF THE GAS

Great harm was done to the gas engine in its early days by the premature publication of the results of an experiment in trying gas which had not been thoroughly cleaned. It was claimed that only primary cleaning was necessary, and that the fine dust left by this simply went into the cylinder and came out again without doing any harm. A few months longer trial, however, soon showed that while most of the dust followed this course, enough of it adhered to the oily surfaces of the cylinder and piston rod to cause the rapid destruction of those parts, and it was then realized, once for all, that the gas must be cleaned, not only in primary washers, but must be scrubbed until the amount of dirt left in it was a negligible quantity. It is said that in present practice the gas passing into these cylinders is cleaner and more free of dust than the air we breathe.

This is not the place at which to deal with the question of gas cleaning, but it seems to be a fact that a positive and reliable solution of this problem, which could be guaranteed, was first obtained by the German engineer Theisen, and after the invention of his apparatus the development of gas-driven engines was much more rapid than before.

ADAPTING THE ENGINE TO VARIABLE LOADS

In Germany the method has largely been adopted of holding open the inlet valve during a greater or less portion of the compression stroke, and so, in fact, cutting down the capacity of the air cylinder when higher pressures were required than those for which the engine was designed. But in this country this plan seems not to have found favor, and in general the gas cylinders have been made large enough to blow the maximum pressure normally required, any change from this being met by adjustment of quantity or quality of gas mixture and enduring the consequent loss of efficiency.

This is for the reason that when a furnace gets "tight" and the pressure goes up, it is frequently, if not generally an indication that it needs more air and if this be not supplied a scaffold is liable to form causing weeks or months of trouble.

Therefore the plan of reducing the volume of the blast in order to attain the increased pressure needed does not commend itself to furnace men; it is good for the engine, but likely to be very bad for the furnace.

ADAPTING THE ENGINES TO RUN DOUBLE ACTING WITH TANDEM CYLINDERS

The difficulties which prevented this development in the early days were those which came from the intense heat acquired by any surface of small curvature, such as a piston rod, unless it was water-cooled. The head and barrel of gas-engine cylinders have been water-cooled since the very beginning, but on account of the mechanical difficulties the early engines were made single acting and their pistons were not so cooled but made long and allowed to get their cooling effect from the barrel of the cylinder and from the air in the crank chamber. This, with the plain flat piston heads without projections, enabled them to run without getting so hot as to cause premature explosions.

When it became necessary to obtain more working strokes per cycle the trunk piston was discarded and the regular piston and piston rods of the standard engine substituted, except that these were both made hollow and water-cooled by flexible or trombone connections to the cross-head or to the rear end of the piston rod. This having been brought into successful practice, the next step was to add a tandem cylinder and run the piston rod through to its piston, and with the experience based on the previous work this was soon brought into successful operation.

In the four-stroke cycle gas engine only one stroke of four is a working stroke instead of every one, as in the steam engine. Therefore by putting two double-acting cylinders tandem and having their working strokes alternate one with another two working strokes per revolution were obtained as in the steam engine. This resulted in an enormous reduction of the irregularities of power development and turning moment, from which the early gas engine suffered.

ELIMINATION OF DIFFICULTIES AND UNCERTAINTIES OF OPERATION

This has been even more than the others a matter of patience and detailed attention to small and apparently unimportant points. The ignition system which was at one time under electrical control and with only one igniter per cylinder head, has now been made entirely mechanical with two or more independent igniters per cylinder end, so that one will ignite the charge if the other fails. Pilot lights on these igniters show whether they are working or not and enable difficulties to be cured before shut downs from the failure of both can occur.

The type of design which has the strength to resist the heavy internal pressures due to the gas explosion, and at the same time is so free from inequalities as to avoid heating strains, and the cracking and failing of cylinder heads and pistons which come from that cause, has gradually been evolved. The system for supplying water for cooling the pistons and piston rods has been developed so that the formation of air and steam pockets is prevented, and the overheating and premature explosion and cracking which arose from those causes are thereby avoided.

In this country the center crank construction has been discarded in favor of the over-hung single crank because the latter requires only one bearing, and definite

knowledge of its adjustment and condition and of the stresses upon it are obtainable, whereas when the center crank is used, two main bearings are required, and the rocking stresses which may be developed by the maladjustment of one of them are enormous and entirely impossible to determine.

The valves of the engines have been put in convenient and accessible locations so that they can be readily removed for examination or replacement, and at the same time so that dirt will not lodge upon their seats, with the consequent destruction of the latter.

All of these details and many more have been subjected to the most rigid, patient, and penetrating investigation, so that the causes which led to these difficulties have either been avoided altogether or their results have been overcome to the best advantage.

EXPENSE OF OPERATING AND MAINTENANCE

The thorough cleaning of the gas eliminated at one stroke a great number of the operating difficulties of the gas engine, while hand in hand with this went the knowledge obtained by both designers and operators from the patient investigation of and improvement of details described under the fourth heading so that great plants of gas engines may now be seen running apparently with but little more attention and no more repairs than would be required by an equal number of steam engines of similar power.

THE REDUCTION OF THE GAS ENGINE TO STANDARD PRACTICE

The gradual elimination of the experimental work required in the early days of its development, and the fact that a number of reliable and experienced engine builders have undertaken its manufacture under competitive conditions, have all tended to reduce the first cost of these engines, while the standardization of designs and better adaptation of the means to the end sought have lowered their rate of obsolescence so that the amortization period is longer and this in conjunction with the lower first cost has greatly reduced the overhead charges.

Type of Gas Engines

Owing to the length necessary on account of their tandem cylinders and to the excessive stresses to which they are liable from the nature of their working cycle, gas engines in large sizes for the iron and steel industries have never been built except as horizontals, therefore the number of types is very much more limited than is the case with steam blowing engines.

The first installation of gas blowing engines on a large scale in this country was that of the Lackawanna Steel Company at Buffalo, which was started about 1903-04, and has been the bone of many bitter arguments pro and con on the whole gas engine situation and on the particular type of engine installed. These are two-stroke cycle engines built under the Koerting patents.

They have a single double-acting cylinder on each side and every alternate stroke is a working stroke exactly as in the steam engine, their gas and air being supplied them by large pumps driven by cranks in the ends of the main shaft, one of which supplies the gas, the other the air, not only for combustion, but also for scavenging the cylinder of the burnt gases from the last stroke. This is done by a "plug" of air which is driven through the cylinder behind the burnt gases and in front of the fresh charge and to a great extent prevents the mixing of these, which would greatly reduce the efficiency.

No exhaust valve is used. The piston uncovers an annular port in the cylinder near the end of its stroke and the burnt gases and plug of scavenging air escape through this while it is uncovered. During the latter part of this interval the fresh charge is introduced into the rear end of the cylinder, but is prevented from escaping by the air plug.

This engine then avoids the necessity of having two cylinders to make each stroke a working stroke and avoids the exhaust valves of the four-stroke cycle, but does so at the price of two large crank-driven pumps which have to raise the charge to higher pressures to force it into the cylinder than is necessary in the four-stroke cycle in addition to which the air required for scavenging only, must be handled and compressed. These engines after more than ten years of continuous service are still in regular operation and, although steam-blowing engines are installed, they are held in reserve and the gas engines run by preference not only of the mechanical department, but also of the furnace manager, because they are not only more economical but require less attention and repairs than the steam engines.

The gas-cleaning installation at this plant is almost rudimentary as compared with more modern ones and the resulting gas much less clean, yet these engines are operating successfully with the original cylinders in some cases without even being bored out and lined with some of the original piston rods and almost all the original pistons.

These engines have horizontal gas cylinders and vertical air cylinders concerning which construction no more need be said than was said concerning the steam engine of that type, except that the high speed and great inertia of the reciprocating parts of the gas engine makes it even more unnecessary than in the steam engine, and it has not so far as I know been used in any other large installations of gas blowing engines in America.

Judged by the test of time and service this installation must be judged as great a success as an initial installation of any kind ever is. It was described in much detail by Mr. E. P. Coleman in Vol. XXXII of the *Transactions* of the American Society of Mechanical Engineers in which excellent article the statement is made that these engines require about 18,500 B.t.u. per indicated horse-power in the air cylinders, an efficiency of 13.7 per cent.

Recent types of four-cycle engines at three-quarter load give about 22 per cent efficiency at the shaft and reducing this by 10 per cent we get 20 per cent as the efficiency based on the indicated horse-power in the air cylinder or nearly one-half more than of the Koerting engines, so the reason for the exclusive use of the four-cycle type is not far to seek. At the same time these four-cycle engines represent a much more recent state of development than do the Lackawanna engines and it is claimed that the later examples of this Koerting type in Eprope give far better results than do the earlier ones. Still it must be acknowledged that while many attempts have been made to improve the economy of the two-cycle engines for all uses and in all sizes none of these attempts have ever succeeded in putting it in the same class for economy as the four-cycle, and it may now probably be said with safety that there are fundamental obstacles to success in this endeavor which will never be overcome.

Fig. 42 shows a gas blowing engine built by the William Tod Company with twin tandem gas cylinders on one side of the crankshaft and a blowing cylinder on the other side, driven by stretcher rods as described for the inside crank steam engine. This construction is no shorter than that of a straight tandem engine, and as the piston rods pass through the cylinder heads, and are supported by slides outside them in all cases,

I do not fully understand the advantages of this construction, but it is in extensive use and seems to give good satisfaction.

Fig. 43 shows a similar design of engine built by the Allis-Chalmers Company, and Fig. 44 shows one of the largest installations of gas blowing engines in this country, also built by the Allis-Chalmers Company.

yet design and build regularly gas engines of the same stroke to run from 70 to 85 revolutions, and the situation is made the more remarkable by the fact that the reciprocating parts of the gas engine are about 50 per cent heavier than those of the steam blowing engine of similar capacity. This, with their high rotative speeds, double those of many steam engines, makes the inertia

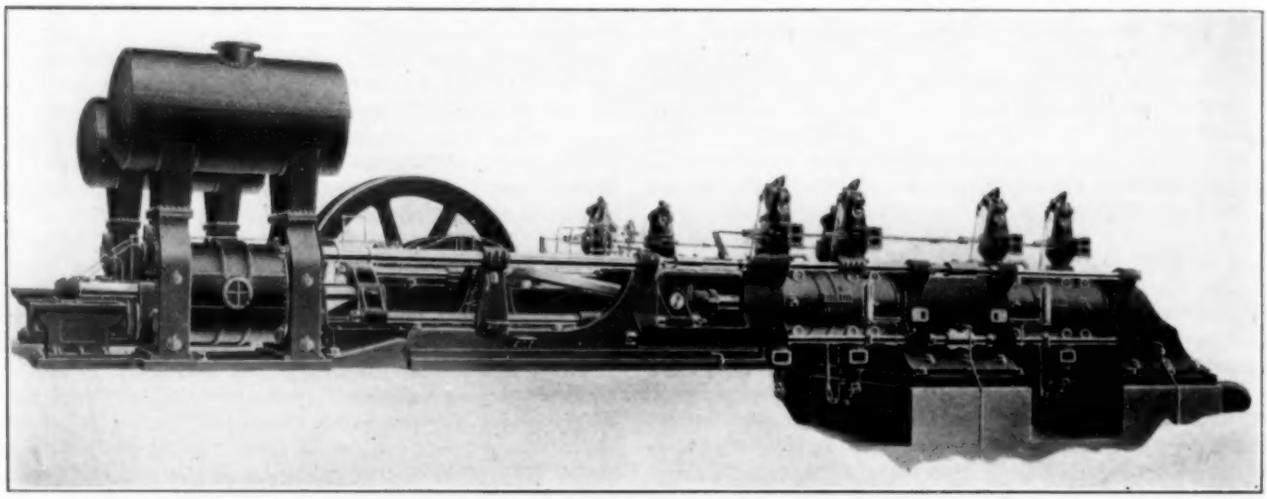


FIG. 42—42 AND 80 X 60 GAS BLOWING ENGINE

Fig. 45 shows in outline a straight tandem gas blowing engine built by the Mesta Machine Company with the crankshaft at one end and the blowing cylinder at the other, a design which I prefer to the inside crank type.

All these engines are of the four-stroke cycle, double-acting, double-tandem type with admission valves and exhaust valves all in the central vertical plane to give maximum accessibility without the necessity of removing cylinder heads and avoid the formation of pockets in the cylinder heads.

The details of the designs differ but not very much more than the details of steam engines.

about six times as great as it is in the steam engine. The set of indicator cards from a gas-driven blowing engine, obtained through the kindness of the William Tod Company, of Youngstown, and shown by Figs. 46, 47 and 48, are from a 42 and 80 by 60 gas engine with a rated speed of 65 revolutions, with reciprocating parts weighing 94,500 lb. for each side.

From these I have prepared the net pressure diagrams for a pair of gas cylinders and the corresponding air cylinder, shown in Fig. 49. These have been reduced into a combined net pressure diagram of both sets of cylinders, shown in Fig. 50, on which is drawn

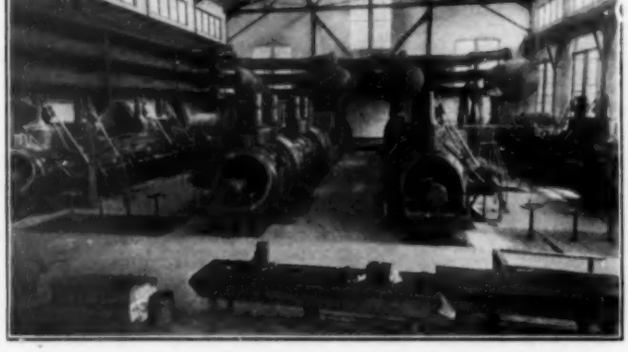


FIG. 43—ALLIS-CHALMERS 44 X 60 TWIN TANDEM GAS ENGINE WITH 60 X 60 AIR CYLINDERS

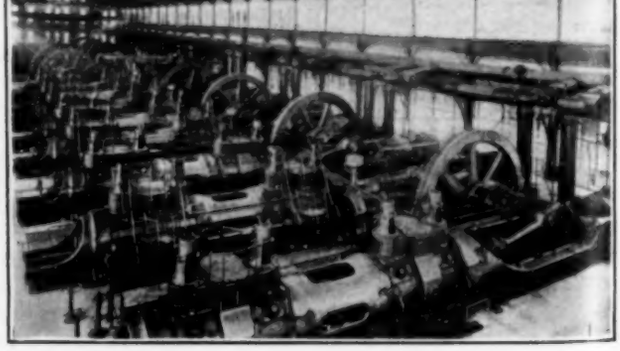


FIG. 44—ROW OF EIGHT ALLIS-CHALMERS GAS BLOWING ENGINES

The air cylinders do not differ from those of steam engines except that the speeds at which they are required to run average higher and the valves must be designed to meet this condition.

THE SPEEDS OF GAS ENGINES

It is a remarkable fact that a number of builders of blowing engines should balk at the idea of running a steam-driven blowing engine more than 40 revolutions,

the line of inertia effect at 65 revolutions and in dotted lines the inertia effect at 60 revolutions.

In Fig. 51 is shown the resultant of these combined air, gas, and inertia diagrams at 65 revolutions. It will be seen that the equalization of power developed and power absorbed by this means is very good, but that the speed is, in this case, if anything a little too high, and that a better equalization would be obtained at 60 revolutions.

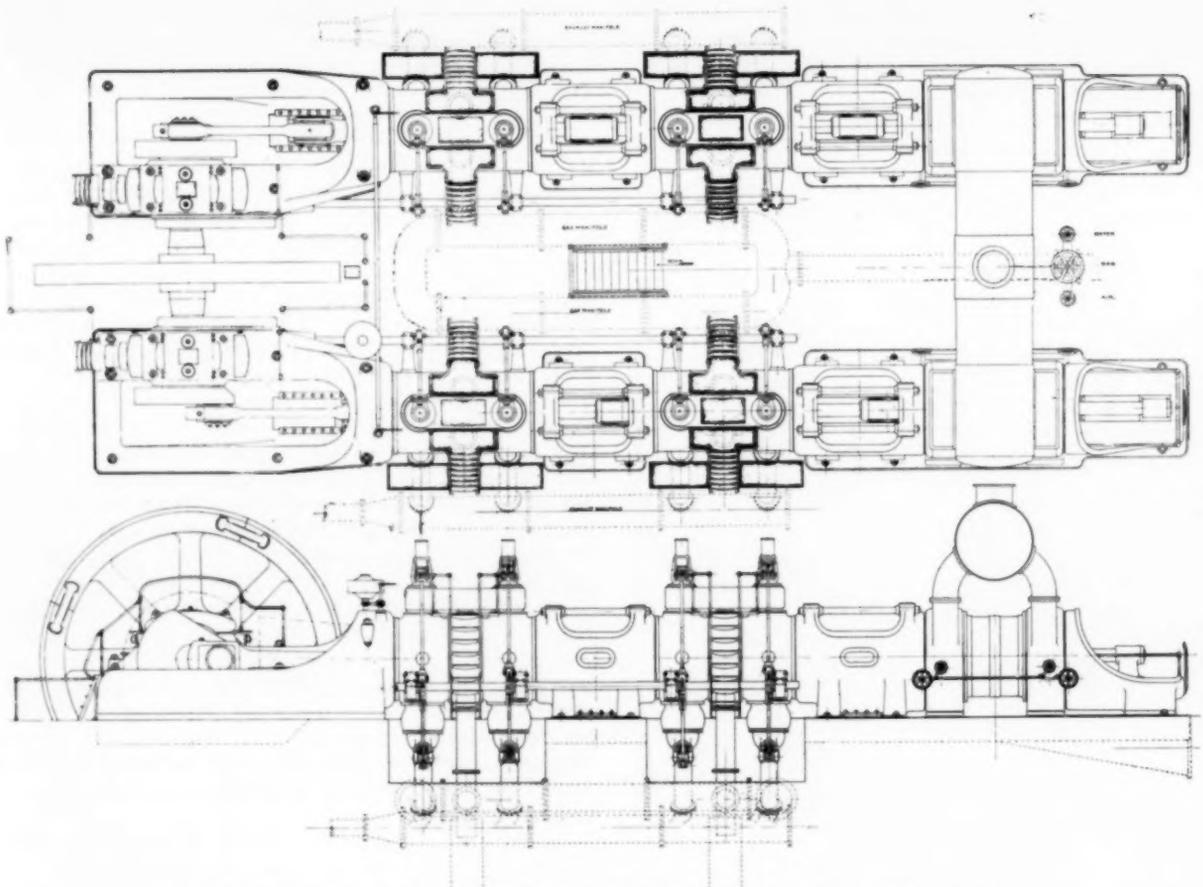
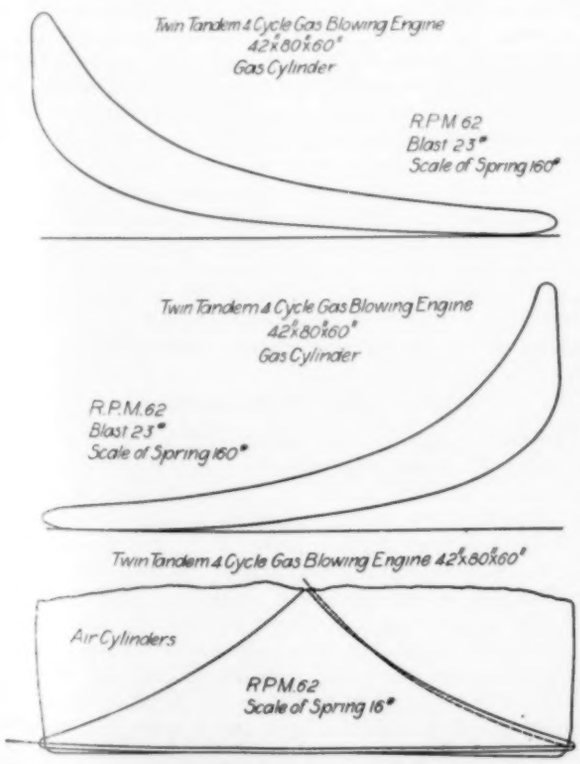


FIG. 45—MESTA GAS BLOWING ENGINE TWIN TANDEM ARRANGEMENTS

The stroke of this engine is 5 ft., that of the horizontal cross-compound, of which inertia and combined diagrams were presented earlier, was 6 ft., only 20 per cent more. It seems remarkable that this engine should be run at a speed of 65 revolutions, while the rated speed of the steam engine was only 40 revolutions, although it would obviously do better work if its detail proportions were right, at 55 revolutions, than it would at 40, with an increase in output of practically 40 per cent and without any countervail disadvantage.

I think the explanation is that the gas engine sim-



FIGS. 46 TO 48—TOD GAS ENGINE CARDS

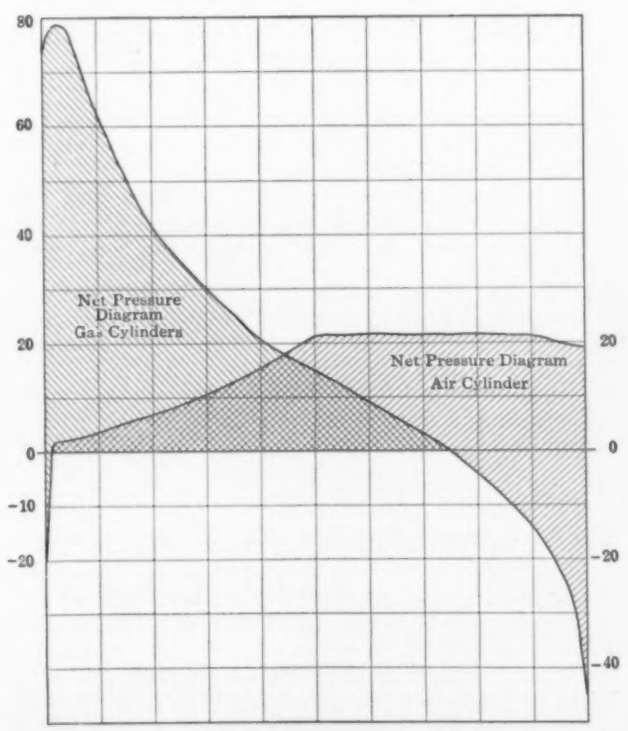


FIG. 49—NET PRESSURE DIAGRAM

ply will not run properly at low speeds on account of the frightful variations in pressure, and the reverses of stress consequent on them, and engine builders have been compelled to run them at a proper speed whether they would or not; while in the case of the steam engine the reversals of stress were so much less severe that the engine could endure them without the equalizing influ-

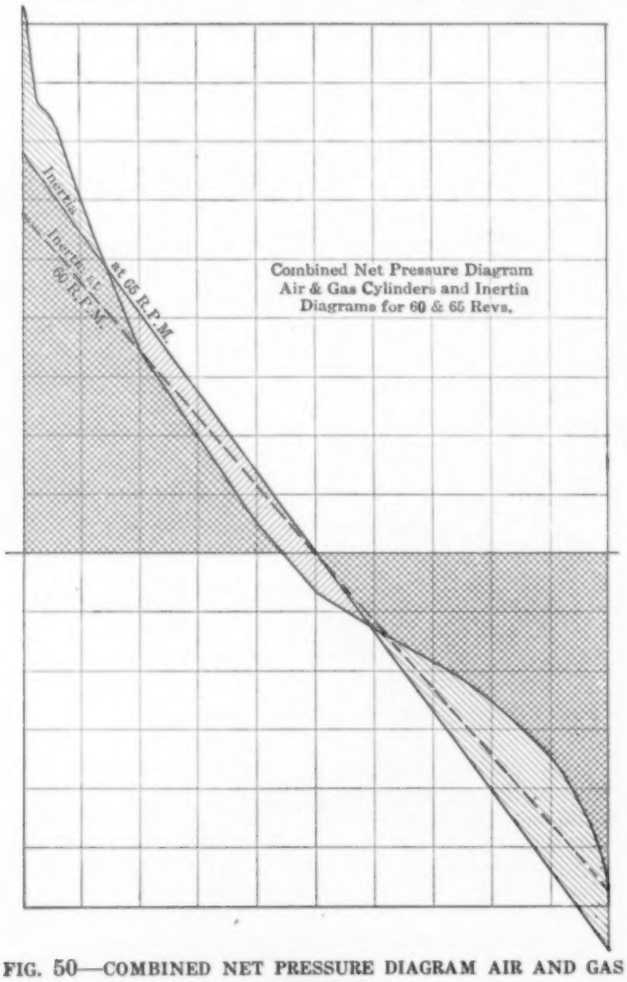


FIG. 50—COMBINED NET PRESSURE DIAGRAM AIR AND GAS CYLINDERS

ence of the inertia effect and the obvious advantages of higher speed have been ignored because the engine could make out without them.

It may be of interest to point out here also the "spike" of pressure due to the reëxpansion of the air in the clearance space which increases the total pres-

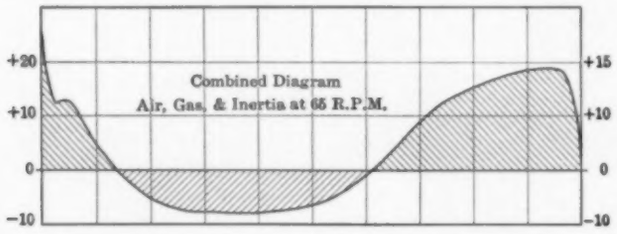


FIG. 51—COMBINED DIAGRAM AIR, GAS AND INERTIA

sure on the running parts of the engine 15 or 20 per cent above what it should be at the beginning of the stroke.

It would seem that by delaying the ignition very slightly the explosion line of the diagram could be made to slope forward by a very small amount so as to offset the pressure from the reëxpansion of the clearance air and that this would not lessen the area of the diagram by an appreciable amount, while it would reduce the maximum stress on the whole engine to an important extent.

The Choice of a Type of Blowing Engine

From what has been said it will be seen that we have the choice of three very separate and distinct types of blowing engines. It would be very desirable to make a definite pronouncement as to the superiority of one of these types, but it is not possible to do this for two reasons. First, the whole matter is in a state of active controversy at the present time, with the advantage shifting from side to side as one receives additional light upon one or another phase of the situation. Second, there is no definite solution for all cases because the conditions vary greatly.

At a steel plant which has within itself a vast market for power, the power producing capacity of the blast furnace gas must obviously be utilized to the fullest possible extent, so that the purchase of other fuel may be minimized or eliminated, and for this object an investment may be made of from four to eight times the annual net saving, depending upon the conditions and the judgment of the owner.

On the other hand a furnace set down in an isolated location with no other manufacturing or mining operation nearby to supply a market for its power is justified in putting in machinery only so good as will secure for its virtual immunity from the purchase of coal for power purposes, and will give the lowest operating cost exclusive of fuel.

Under these conditions it is obvious that no decision of this question for all cases is possible even if the actual physical data of operation available were complete, and were unanimously admitted by all parties in the controversy, which is by no means the case. The problem must be solved for each case on its own merits, and the lines of this solution may in a general way be laid down. It may be said in advance that recent investigation of this subject with details of actual capital and operating costs of gas engine plants by Messrs. H. J. Freyn, formerly of the Allis Chalmers Company; C. J. Bacon, of the Illinois Steel Company, and Arthur West, of the Bethlehem Steel Company, with data on the steam turbine and turbo blower, submitted by Mr. Richard H. Rice, of the General Electric Company, have indicated that the fuel cost of power production is by no means the only cost, and in many cases is not even the largest item, but that as we pass from the plain and simple types of machinery of old, to the more refined and economical but expensive types of to-day, the fixed charges due to investment rise at a rate which may equal or exceed that at which the value of the fuel saved falls. It is only by considering all these factors that we can arrive at the proper solution in any given case.

The Outline of the Solution

The first question to be asked and answered is as to the value of power for purposes outside the blast furnace. If no market is at hand or can be created this is obviously zero. If on the other hand there is a market it is obvious that surplus power produced by the furnace must meet the competition of power produced by the cheapest means otherwise available. This will generally be determined in a broad way by the cost of coal at the given locality. Granting the existence of the market for the power at a price so determined, and knowing the quantity of gas to be produced by the given furnace plant we deduct from the former 40 per cent to represent the consumption of the hot blast stoves, and 5 per cent for other auxiliaries around the plant,

the remaining 55 per cent is the gross amount which must supply the power required for blowing the furnace and that which is to be sold.

Fairly reliable figures are to be had as to the number of thermal units required per horse power, by each of the different types of prime movers. In the case of the gas engine this can be converted directly into cubic feet of gas required, based on the thermal units per cubic foot of the gas after it is cleaned and cooled and ready for the gas engine cylinders. But in the case of the steam engine and the steam turbine the efficiency of the boiler enters as a factor of much importance. It has been claimed that this may be put as high as 80 per cent, but the best and the most recent data concerning boilers and their operation with blast furnaces gas, indicate that they often reach in practice something less than 60 per cent. This also, however, is capable of investigation and determination for the detailed case in contemplation, and a figure corresponding to the results which may reasonably be expected, must be taken. Due allowance must be made for the steam pressure desired, and particularly for the degree of super-heat desired in the steam, and for the fact that the actual quantity of heat required in proportion to the theoretical is greater as the degree of super-heat rises.

With this information we may figure the number of cubic feet of gas required to produce a horse power in the case of the steam engine and the steam turbine, and in this case the thermal value of the gas per cubic foot in a partly cleaned and warm condition may be taken instead of that for its cold condition, which makes a difference of between 5 and 10 per cent in favor of the steam apparatus. This helps to offset the initial advantage of the gas engine that it only requires about two-thirds as many thermal units per brake-horsepower as do the steam driven motors.

We can now figure the quantity of gas needed to blow the furnace in each case and subtracting this from the total net heat available we obtain the amount available for the development of power to sell. From this we may determine the amount of such power we can produce in each case and its value, from which the operating cost of its production, exclusive of fuel, must be deducted. Against this we must set up the cost of the investment, the proper rate of amortization, and the proper rate of interest on the capital in each case. By comparing these with the net earnings for the power sold in each of the three cases, we can determine which is the best investment, always remembering that the amount of money available, or which can be raised, is more often than not strictly limited, and that the fact that a fine interest can be earned on an extra two or three millions is of little interest or value if the management cannot raise the extra two or three millions. It is also very necessary to remember that the type of motor determined upon as best to blow the furnace is not necessarily the best for developing power for sale. In fact in my judgment the probabilities are that the reverse is the case. The steam turbine owing to rotary motion, high steam economy, and ease of supervision has great advantages in driving electric generators, whereas for driving blowers it has no better means to apply to the purpose than the turbo blower whose efficiency is only 70 per cent as a maximum as compared with 85 per cent or more as the over-all efficiency of the piston blower. This gives the reciprocating engine, whether steam or gas driven, a long lead over the turbine for blowing purposes, while it has as outlined above many advantages over them in the generation of electric power.

For all these reasons it seems well to reiterate that each case presents a problem of its own which must be handled without prejudice by someone competent to weigh not only the technical considerations involved, but also that more serious and more difficult question which has wrecked so many engineers and their brilliant schemes: *How much interest will it pay on the capital invested?*

Notes on Chemistry and Metallurgy in Great Britain

(From Our Special Correspondent)

The Institution of Mining and Metallurgy

At the annual general meeting of this institution, on March 26, Dr. **F. H. Hatch** delivered his presidential address and took as his subject "The Relation of Geology to Mining." He said that originally the science of geology was founded to a considerable extent on the facts observed by miners; but at the present the situation has become reversed and mining is largely dependent on geology. There were many instances of successful mining operations resulting from the application of geological science: but the importance of geology in relation to mining was even greater than was generally recognized; and its due appreciation would involve either a more extensive training in geology on the part of the mining engineer or the cooperation of the mining geologist. With regard to modern views on the origin and formation of metalliferous ores, it was remarkable that British geologists, with very few exceptions, appeared to look on the questions of ore-deposits as a matter exterior to pure geological science.

It was announced that the number of members of the institution on December 31 last was 2,372, an increase of 114 during the year 1913.

The British Westinghouse Company

The report for the year ended on December 31, 1913, shows that the position of the British Westinghouse Electric and Manufacturing Company has undergone a material improvement; and contains the satisfactory announcement of a 5 per cent dividend on the 15 per cent Preference Shares. The gross profit for the year is £223,103, out of which £44,100 for depreciation, £6,728 for redemption of Six Per Cent Prior Lien Debentures, £13,272 for interest on the Six Per Cent. Prior Lien Debentures, £49,645 for interest on Four Per Cent Mortgage Debentures, and £2,856 for expenses on surplus land and buildings are deducted; leaving £106,494 net profit. The dividend on the Preference Shares absorbs £50,000; £50,000 are carried to general reserve, and the balance of £6,494 is carried forward. The balance brought forward from 1912, amounting to £66,899 was devoted to the reduction of capital.

FLAMELESS COMBUSTION

Professor **W. A. Bone,** in a recent lecture at the Royal Institution, described the principles and applications of the system of surface combustion devised and carried out at Leeds by himself and Mr. C. D. McCourt.

In its simplest form the apparatus for incandescent flameless combustion consists of a diaphragm of porous refractory material mounted in a suitable casing forming a chamber into which an explosive mixture of gas and air, in the proportions requisite for complete combustion, is admitted under slight pressure. Combustion goes on at and under the surface of the diaphragm, which becomes highly incandescent, without flame, and is limited to a depth of about 0.25

inch below the surface. Temperature is perfectly controlled by varying the rate of supply of the gaseous mixture, and the apparatus works efficiently in any desired position. The external air does not take any part in the combustion, and incandescence can be maintained in an atmosphere of carbon dioxide.

For furnace operations, heating crucibles and muffles, and annealing, the body or substance to be heated is surrounded by a bed or layer of refractory material enclosed in a suitable chamber and the gaseous mixture is injected into the poruos bed at a speed high enough to present back firing. A No. 39 Seger cone with a melting point of 1880 deg. C. has been melted in a crucible fired by a coalgas-air mixture; platinum can be melted without difficulty, and the temperature of a muffle can be maintained at 800 deg. to 1400 deg. C. with a gas consumption from 30 to 60 per cent less than that of an ordinary flame furnace of the same size. Satisfactory reports have been made on the working of some large annealing furnaces using Mond gas and town gas, and the melting of 50-lb. to 60-lb. charges of brass in tilting crucible furnaces has been effected with a consumption of only about 1.75 cu. ft. per pound of metal melted. The process admits of the use of any kind of gaseous or vaporized fuel of the requisite calorific value.

The great value of the invention in its application to steam boilers has been proved in practice. The heating tubes have an internal diameter of 3 in., and are packed with refractory material into which the gaseous mixture is forced through an inlet in the center of a plug of fire-clay, closing one end. Trials of a boiler so heated, at Skinningrove Iron Works in July, 1912, after five months' working, showed the utilization of 92.7 per cent of the net heat supplied, while 4.3 per cent was lost by radiation, etc., and 3 per cent in the products of combustion, but none at all in unburnt gas. A second installation has recently been made at the same works, and the firm of Krupps has been successfully using a boiler heated on the Bone-Court system since last October. Reports of the official steam trials of this boiler early in February confirm the results obtained at Skinningrove. The lecturer complained of this "purely all-British invention,"[1] having been described in the German technical journals as the "Bone-Schnabel" or "Schnabel-Bone" boiler instead of the "Bone-Court."

Determination of Zinc in Bronze Coinage

Dr. T. K. Rose, assayer of the Royal Mint, read a paper before the London Section of the Society of Chemical Industry, in which he said that it had been decided to revive the old method of estimating zinc in coinage bronze which was abandoned about the year 1870. That old method had a great advantage in economizing the time occupied, and in fact, demanded only about five minutes personal attention for each estimation.

The method was very simple and was effected by heating one gramme of the alloy in a reducing atmosphere at a temperature of 1375 degrees for two hours and taking the weight of the residue. The details are as follows:

The one gramme sample is placed in a carbon crucible provided with a well-fitting lid, and from 8 to 16 of these crucibles are imbedded in charcoal in a graphite pot and subjected to the temperature named in an injector furnace. The composition of coinage bronze is copper 95 per cent., tin 4, and zinc 1. The loss after two hours' heating as described was found to amount to between 1.2 and 1.3 per cent., which was explained by the fact that whilst about 0.03 per cent. of the zinc was retained there was a large loss of copper, amounting to about 0.2 per cent.

With each batch of assays a sample from a trial plate of known composition was included, and the results, after correction, showed a variation of from 0 to 0.1 per cent., the average coming out at about 0.02 or 0.03 per cent.

Determinations have been carried out by this method, on alloys of zinc containing various amounts of that metal, up to as much as 90 per cent., and the results obtained were in very good agreement with those furnished by gravimetric and volumetric methods.

A noteworthy fact, however, was that as the percentage of zinc increased from 1 to 90 the copper loss during the heating grew to twice as great and rose to 0.4 per cent.

[1]Concerning the early American work of Dr. Chas. E. Lucke on surface combustion see this journal, Vol. X, page 409 (July 1912).

Market Prices, March, 1914

Tin opened £174, and fell away to £172-£173, about which price it remained till the 17th, hardening to £174.5 on the 18th and to £175.5 on the 23rd, and touching £176.10 on the 24th, since easier and closes at £173.10.

Copper opened at £64, and declined gradually to £63.7.6 (13th), recovering to £64 on the 19th, and to £64.13.9 on the 23rd, and rising as high as £65.7.6 on the 24th; then eased slightly, closing at £64.17.6.

Haematite remains firm at 61/- and closes at the same price.

Cleveland opened at 50/6 and has remained close to this price; it was 50/4½ on the 13th and 50/9 on the 18th, since easing slightly, but closing at 50/9.

Scotch Pig opened 56/6 and has been either at or close to this price, closing, however, a little higher at 56/9.

Lead opened at £20 and was at first inclined upwards, being £21.10 on the 10th, and, after a drop of 2/6 on the 13th and 16th, it became rather quieter, closing £20.5.0.

Differences

Higher	£	s.	d.	*Lower*	£	s.	d.
Copper ore, unit			4½	Aluminium, ton	1.	0.	0
Copper, ton		10.	6	Caustic soda, ton		5.	0
Lead		5.	0	Quicksilver, flask		10.	0
Cleveland			3	Sulphate of ammonia		6.	3
Scotch pig			3	Shellac, cwt.		2.	6
				Tin ore, ton	6.	0.	0
				Tin, ton	2.	0.	0

	£	s.	d.
Aluminium, ingots, ton lots	85.	0.	0
Alum, lump, loose, per ton	£5.5 to 5.10.		0
Antimony, Star Regulus, per ton	£28 to 29.	0.	0
Borax, British refined crystal, cwt	17/6 to 18.		6
Copper sulphate, per ton	22.10.		0
Caustic soda, 70%, per ton	10.	0.	0
Copper ore, 10% to 25%, unit	10/10½ to 11.		4½
Ebonite rod, lb.		4.	6
Hydrochloric acid, cwt.		5.	0
India rubber, Para, fine, lb.		3.	0
Mica, in original cases, medium	3/6 to 6.		0
Petroleum, Russian spot, gal.			9¼
Quicksilver (Spanish), bottle	7.	0.	0
Sal ammoniac, cwt.	£2 to 2.	2.	0
Sulphate of ammonia, ton	12.	6.	3
Sulphur, recovered, ton	5.10.		0
Shellac, cwt.	3.11.		6
Platinum, oz., nominal	9.	5.	0
Tin ore, 70%, ton	£107 to 109.	0.	0
Zinc, Vielle, Montagne	25.12.		6

Steel castings direct from iron ore are now being made in the electric furnace by the Moffat-Irving Steel Works, Toronto, Canada, according to the *Canadian Engineer*. Average analysis of three heats is reported as C, 0.27 per cent; Mn, 0.74 per cent; Si, 0.27 per cent; S, 0.01 per cent; P, 0.031 per cent.

Electric furnaces of the Heroult type are used by the National Malleable Castings Company at the plant at Sharon, Pa., for the manufacture of electric steel castings for automobile and locomotive parts. A booklet issued by the company gives information regarding the advantages of electric steel castings.

New York Convention of American Electrochemical Society

Report of Proceedings, and Abstracts of Lectures and Papers Presented

The twenty-fifth general meeting of the American Electrochemical Society was held in New York City on Thursday, Friday and Saturday, April 16, 17 and 18. The attendance was excellent, there being more than 300 members and guests registered, and the meeting was a success in every respect.

The arrangements of the meeting were in the hands of the New York Section of the Society and the fullest credit must be given to the untiring efforts of its officers, Mr. Lawrence Addicks, chairman, and Mr. H. B. Coho, secretary and treasurer, as well as to the chairmen of the committees which had the different social functions and entertainments in their care. Mrs. L. H. Baekeland was the chairman of the Ladies' Committee, Mr. Lawrence Addicks was in charge of the steamer excursion on Friday, Mr. H. B. Coho of the smoker on Thursday night. Mr. Jacob Hasslacher, as chairman of the finance committee, made possible a lavish entertainment of the visitors. Mr. George C. Stone was in charge of the dinner-dance on Saturday night, Professor Arthur L. Walker was chairman of the reception committee, while the *Convention Daily*, published in three issues by courtesy of *Metallurgical and Chemical Engineering*, was in charge of Mr. J. Malcolm Muir, as chairman of the Publication Committee, and Mr. H. C. Parmelee as editor.

F. AUSTIN LIDBURY,
PRESIDENT AMERICAN ELECTROCHEMICAL SOCIETY

Business Meeting

The annual business meeting of the Society was held at the beginning of the first technical session on Thursday morning at The Chemists' Club. President E. F. Roeber called the meeting to order at 9 a. m. and Mr. Lawrence Addicks, chairman of the New York Section, extended in a felicitous little speech the greeting of the New York members to the visitors.

Dr. J. W. Richards then presented the annual reports of the secretary and treasurer, which showed the Society to be in a flourishing condition. The number of members on Dec. 31, 1913, was 1376; it is now about 1400. The assets of the Society, invested in bonds, amount to over $6,000.

Dr. W. R. Whitney called the attention of the members of the Society to the organization of the International Electrical Congress, which will convene in San Francisco next fall. The American Electrochemical Society will hold its fall meeting of 1915 in connection with the Electrochemical and Electrometallurgical Section of this Congress.

The result of the annual election of officers was then announced as follows:

Mr. F. Austin Lidbury, works-manager of the Oldbury Electrochemical Company, Niagara Falls, N. Y., is the new president.

Mr. Pedro G. Salom and Dr. Joseph W. Richards were re-elected treasurer and secretary respectively.

Dr. Carl Hering, Dr. Wilder D. Bancroft and Dr. William Brady were elected vice-presidents; Mr. H. C. Parmelee, Dr. W. R. Whitney and Dr. Colin G. Fink, managers.

Smoker

On the evening of Thursday the retiring president, Dr. E. F. Roeber, presented at The Chemists' Club his address on "Some Economic and Aesthetic Aspects of Electrochemistry." This is printed in full on page 344.

This was followed by a smoker which was very entertaining. The idea of the smoker was Election Night of Section Q. Mr. Coho, as chairman of the smoker, explained that at the last general meeting of the Society in Denver a certain wealthy mine owner was so impressed with the serious worth of Section Q that on his death he bequeathed to the section a complex-zinc-ore mine in Mexico. The question immediately arose, "What shall be done with the mine?" It was finally decided to hold an election to select a group of men and a process and work the mine. Three tickets had been in the field and the electioneering had been furious.

The Wet Party advocated a wet process for treating the ore. The Drys favored dry ore treatment, while a third party had arisen from the desire of the Bureau of Mines to run this mine and after an amalgamation with the I. W. W. advocated a fusion process.

Mr. Coho explained that the election returns were now coming in and that bulletins from various districts would be flashed on the screens. These bulletins were a source of much pleasure, being appropriately grotesque. Between bulletins the stereopticon operator flashed portraits of members of the electrochemical rougue's gallery, with verses setting forth their accomplishments in nursery rhymes. Then there were moving pictures, songs and presentations, mixed with the enjoyment of beer, pretzels and cigars.

An election bulletin finally announced that the complete count of the ballots showed that the candidate of the Wets had received 6000 votes, the Fusion candidate 505, and the candidate of the Drys 2 votes, whereupon, in accordance with the new constitution of Section Q, the result was referred to the Council for final action.

In the meantime the candidate of the Wets, being apparently the successful candidate, was called on for a speech. He was interrupted, however, by the announcement that the Council had met and unanimously elected the Dry candidate president of Sec-

tion Q and director of the zinc mine. Just here a wireless was received to the effect that the Fusion candidate protested agains the high-handed methods of the Council.

The fun was greatly enjoyed. About 11 o'clock a Dutch lunch was served and the members dispersed at a late hour.

Boat Excursion on Friday

The boat excursion on Friday, in charge of Mr. Lawrence Addicks, had been equally carefully planned. The steamer *Isabel* had been hired to take the party down through New York Harbor to the Narrows and then around Staten Island to Perth Amboy.

MAP OF NEW YORK HARBOR AND METALLURGICAL PLANTS

The rain of Wednesday and Thursday threatened to spoil the excursion and there were many silent prayers for a change in the weather. When Friday morning came it was a beautiful day and nearly 200 members and guests with ladies participated in the steamer trip. The sights of New York Harbor were greatly enjoyed in the crisp spring morning. The entertainment on board included music and dancing, a luncheon and tea.

The works of the American Smelting and Refining Company at Perth Amboy and the adjoining plant of the United Lead Company were visited in the early afternoon and on the return trip the copper wire-drawing mill of the Waclark Wire Company in Elizabethport. A separate party went from Perth Amboy with Mr. Alfred H. Cowles to his plant in Sewaren, where his new alumina process is being tried out on a large scale.

The accompanying map shows the location of the plants visited; it is reproduced here from the *Convention Daily*. The map had been published originally in the *Engineering and Mining Journal*, but for the purpose of illustrating the boat trip the names of a few plants have been added. The map is interesting in illustrating New York City as a metallurgical center.

Dinner Dance

The meeting was concluded by a dinner dance in The Chemists' Club on Saturday night, in charge of Mr. George C. Stone. The banquet was held in Rumford Hall. Mr. Lawrence Addicks was a very clever toastmaster. Speeches were made by the retiring and incoming presidents, Roeber and Lidbury, by Professor Bancroft, and by Mrs. L. H. Baekeland, whoe spoke beautifully of the proper sphere of influence of the modern woman. Dr. L. H. Baekeland then presented to the retiring president, Dr. Roeber, a beautiful silver loving cup "from his many friends."

Dancing followed in the social rooms of The Chemists' Club and was indulged in by a large party up to a late hour. Thus the twenty-fifth meeting of the American Electrochemical Society went into history.

Ladies' Entertainment

Mrs. L. H. Baekeland was the genial chairman of the Ladies' Committee and a very fine programme of entertainment had been arranged, including a Thé Dansant at the McAlpin on Thursday afternoon, a theater party, in charge of Mrs. Maximilian Toch, on Thursday night ("Too Many Cooks"), a visit to the Morgan picture collection and an automobile party on Saturday morning, and a tea at the Plaza on Saturday afternoon.

Technical Sessions

There were four technical sessions. Those of Thursday morning and afternoon were held in The Chemists' Club and those of Saturday morning and afternoon at Columbia University. All these sessions were opened by invitation lectures, followed by the reading and discussion of papers, of which printed advance copies were available. The attendance at all technical sessions was very good; it was never below 100, and often reached 200 present.

Power Problems in Electrochemistry

The subject of the first technical session held on

Thursday morning in The Chemists' Club was a symposium of lectures and papers on power problems in electrochemistry, followed by a general discussion. The session was very well attended and lasted from 9:15 a. m. to 12.45 p. m.

Characteristics of Electrical Energy as Affecting Chemical Industries

Dr. Charles Proteus Steinmetz presented a lecture on characteristics of electrical energy as affecting chemical industries. Industrial operations require materials, energy and labor. While the economical supply of energy is important for most industries, it is especially so for the chemical industries. In the chemical industries the cost of materials and energy predominates greatly over that of labor.

Energy is supplied to us by nature essentially in two forms, namely, the chemical energy of fuel, and the hydraulic energy of water powers. Considered merely as the raw material, as bulk source of energy, the chemical energy of fuel is very much cheaper. The lowest cost of energy of fuel as such is 0.01 cent per kw-hour, against 0.1 cent for electric energy from water powers. Hydroelectric energy can compete with the chemical energy of fuel only in those cases where there are compensating advantages.

CHARLES P. STEINMETZ

There are two such cases. First, where electrical energy can accomplish chemical results which cannot be accomplished by the chemical energy of fuel; such processes are reduction of aluminium, production of calcium carbide, and fixation of atmospheric nitrogen. Second, where the economic losses in efficiency and in cost of installation, and economic losses of making chemical energy of fuel available by converting it into the form in which it is used, are such as to make the cost of the energy required by the industry when derived from the chemical energy of fuel higher than the electrical energy derived from water power. The most typical illustration of this kind is the mechanical energy supply. While the chemical energy of fuel costs about one-tenth of what the electrical energy from the water power costs, when we convert the chemical energy of fuel into mechanical energy by steam plant, considering the interest on the investment and the inefficiency of the thermodynamic process as a whole, we find that almost always the cost of the mechanical energy derived from chemical energy of fuel is higher than when derived from the electrical energy transmitted from the water power, other things being equal.

One of the characteristics which makes electrical energy specially suitable for chemical industries is the possibility of concentration to an almost unlimited energy density, so that by electrical energy we can bring about chemical actions which cannot be brought about by the relatively low energy density available by combustion of fuel.

In electric furnaces we can reach temperatures very much higher than the highest temperature possible by the combustion of fuel, even with hot blasts and other auxiliaries. In those fields where a higher energy density is required electrical energy stands without a rival, irrespective of the cost, and the economy of energy supply merely determines the cost of selling and therefore the utility of the product in the industry.

A second characteristic of electrical energy is its control. We can control it very much more closely than the chemical energy of fuel in form of chemical combustion. We can produce electrical energy without contamination by foreign materials. Therefore, electrical energy finds application in chemical or other industrial processes, where a very close control of the energy is called for, and where the contamination by foreign materials, which is practically unavoidable when fuel is used as the source of energy, would be prohibitive.

Another characteristic of electrical energy is its ease and economy of transmission to great distances and its economical distribution, but its predominating advantage is the ease of its conversion into other forms of energy with a very high economic efficiency.

There is, however, one characteristic of electrical energy which is a very serious disadvantage, and that is that electrical energy cannot be economically stored, but must be consumed at the same rate at which it is produced. This makes the cost of electric energy dependent on the rate of its consumption, in the same manner as the cost of energy is dependent on the rate of its production. The cost of electrical energy generated in the same big power station may vary in a range of more than 1 to 200; that is, power may be sold economically and profitably at ½ cent, or less, per kw-hour at times of low load, while power generated during the hours of the peak of the load may cost the station more than $1 per kw-hour. In the analysis of the cost of electrical energy production proper consideration of the fixed charges of the plant is very important. This is particularly true of hydroelectric plants. The station load-factor dominates the cost of energy production.

To secure electrical energy at the lowest possible cost for chemical work it must be used at constant load and continuously day and night throughout the entire year, in other words, at unity load-factor at the consumers' premises.

In electric-furnace work a reactance may be used to intentionally limit the maximum demand. While this would lower the power-factor, this is of less importance in most cases than to exceed a certain maximum demand, because a poor power-factor can be corrected by synchronous condensers at relatively smaller cost than additional generating capacity can be secured to carry peak loads.

As most water powers are subject to limitation of output by low flow of water during certain times of the year, any industry that can afford to shut down entirely or at least partly for several weeks or even months during the drought can reduce the cost of its electrical energy supply. This means that conditions may require an annual shutdown, even with employees receiving full pay, and better net financial results may be obtained in this way than by absolutely continuous operation.

Another possibility of reducing the power cost is the possibility of sudden shutdown, from a minute or so to possibly several hours, on account of failure of transmission lines, because this eliminates the necessity of a steam reserve plant.

The very lowest rate for power can be obtained by those industries which can utilize intermittent and distinctively off-peak power in such a way as to fill the valleys in the station's load curve and bring the station load-factor nearly to unity. The rate for such a load should be considerably lower

than for one taking continuous power throughout the year. If electrochemists can build up such a load, they will get the electric power at the very lowest rates.

Power Transmission Economics

Mr. **P. W. Sothman,** of P. W. Sothman Co., consulting engineers, New York City, presented a paper entitled "Notes on Power Tranmission and Transmission Economics," with special reference to the economy of power transmission versus utilization in local electrochemical industries.

The author first discussed electric power generation from steam, waterfalls, gas producer plants and oil engines, and expressed the belief that the time would shortly arrive when power generated from gas and oil in competition with steam and water power would take a very prominent place in electrochemical work. He gave figures for the initial costs of power plants of the different types, including buildings, and for the cost of electricity per kw-hour on the busbars so developed, including all overhead and maintenance charges. These figures are given in Table I:

P. W. SOTHMAN

TABLE I.

	Hydroelectric Plant	Steam Plant	Gas Producers	Diesel Plant
Initial cost per h.p. of capacity	$125	$100	$100	$100
Power cost per kw.-hour	3.6 mills	6.25 mills	4.95 mills	5.62 mills

These figures are based on a load factor of 60 per cent. and include fixed charges of 11 per cent. on the hydroelectric and steam stations and 12 per cent. on the gas producer and Diesel plants. The high load factors which are attainable in large electrochemical plants favor not only water power plants but also those operated by producer gas and oil, for the high efficiencies of the latter two are most marked when the load factor is good.

Table II. was published a couple of years ago and shows horsepower used per employee in a number of industries:

TABLE II.

	Horsepower Used Per Employee
Tools and implements	0.678 h.p.
Cotton and woolen goods	0.759 "
Miscellaneous manufacture	2.35 "
Paper manufacture	13.33 "
Flour and feed	15.93 "
Lumber and woodworking	6.76 "
Pulp grinding and excelsior	23.00 "

In electrochemical industries power forms one of the chief items of expense of operation.

In discussing transmission of electrical power Mr. Sothman mentioned that transmission at 10,000 volts was first attempted in 1891; in ten years' time the voltage climbed to 50,000, while before the end of 1909 lines at 110,000 volts were in operation. Now the mark has been set at 145,000 volts. The operator of electrochemical works should inquire whether this marked development in transmission cannot be taken advantage of by himself. But each case must be studied for itself.

How far is it possible to transmit energy electrically in usable quantities? Power in any amount may be easily transmitted on a straightaway line for a distance of at least 500 miles, and at that in a thoroughly reliable manner, though at the farther end of the line perhaps only 65 to 75 per cent. of the power may be received, even with the use of liberal-sized conductors.

At the present time there are no less than three long-distance lines in operation at approximately 145,000 volts, and the length of each is close to 240 miles. These are doubtless all well within the present economical distance limit.

In districts where a cheap coal supply is available, such as in certain parts of the East, it is not profitable to transmit power to greater distances than about 175 miles, even when competing with steam, for if the power is required in such quantities as to warrant the construction of a substantial transmission line, it would also warrant the building of a modernly equipped steam plant on the site of utilization which could supply energy at a cost as low as that of the transmitted power.

The use of a modern gas producer, burning coal costing $2 per ton, reduces the economical transmission distance of waterpower costing to generate four mills per kilowatt-hour to approximately one hundred miles.

Mr. Sothman next discussed the choice at voltage. The reason for using high voltage is to keep the conductor cost as low as possible. But with high-voltage lines there are other factors of expense which offset the saving in the size of conductors. Wooden-pole lines with low-priced pin-type insulators may be used for voltages up to 40,000 or 50,000. At 60,000 volts steel towers are almost universally used, the cost of which is higher. As the voltage further increases very expensive pin-type insulators or suspension-type insulators are used. At potentials upwards of 100,000 volts, the effects of corona become manifest. The critical voltage at which corona starts becomes lower with smaller-sized conductors.

In Mr. Sothman's opinion there should be no need of an intermediate voltage between 60,000 and 110,000 volts. The author discussed in some detail the great advances made in insulator design in recent years.

In conclusion Mr. Sothman gave some figures for the costs per mile of transmission line construction suited to different voltages. These are based upon the use of copper cables of No. 000 B. & S. gauge or their equivalent in aluminum. These figures are given in Table III. These costs do not include a telephone line or right-of-way. The wooden poles are assumed to be spaced 120 ft. apart and the steel towers 550 ft. apart. In the total cost of line 10 per cent. has been allowed for engineering and contingencies.

With proper care in the design and selection of materials, specially insulators, coupled with the use of suitable protection apparatus, a modern line should give practically uninterrupted service. But each particular case must be considered upon its own merits. For instance, an insulator may serve admirably on one line and fail utterly to give satisfaction on another line of the same voltage.

In conclusion Mr. Sothman called attention to the value of the peat deposits distributed all over the country. They may become more valuable for power supply than our waterpowers, especially as they are not liable to interruptions like waterpowers. A point

TABLE III.

Description	Towers or Poles Inc. Footings	Cables and Erection	Insulators	Total
12,000 volts.				
Pole Line				
Double circuit..	$1,400	$3,120	$130	$5,115
Single circuit..	1,100	1,600	65	3,042
30,000 volts				
Pole Line				
Single circuit..	1,400	1,650	200	3,575
60,000 volts.				
Steel Towers			Pin Type	
Double circuit..	1,800	3,300	$220	5,852
Single circuit .	1,630	1,700	110	3,784
110,000 volts				
Steel Towers			Suspension Type	
Double circuit..	2,050	3,300	$662	6,569
Single circuit..	1,850	1,720	350	4,312

Copper based on 18c. per lb.

may be reached where the use of peat power plants in conjunction with water power plants may prove advantageous.

Economies of Electric Furnace Operations

Mr. F. A. Fitz Gerald, of The Fitz Gerald Laboratories, Inc., Niagara Falls, N. Y., presented a paper on "Some Economies in the Use of Energy in Electric Furnaces."

"The relatively high cost of the heat unit generated by means of electricity as compared with fuel has led all those interested in the development of electrothermics to give serious consideration to economies in electric furnace practice. While the end sought is most desirable, it is unfortunate that its pursuit has led to much misdirected effort, which, instead of realizing economies, has resulted in waste and consequent retardation in electric furnace development.

"This is not surprising, since the same thing is observed in the pursuit of many other desirable objects, such for example as conservation, efficiency, eugenics, etc. No one will deny that these things are important, and no intelligent observer can fail to see the vast amount of misdirected and even harmful activity generated in relation to them. Perhaps the most striking analogy is found in certain activities for the relief of human ills. Recently there has been extraordinary agitation in favor of inducing the government to take up the mining and manufacture of radium.

"Leaving out all such secondary motives as the creation of bureaucratic jobs, personal advertising, etc., it is found that many people, otherwise intelligent, believe first that cheap radium is one of the most important things for the welfare of the human race, and second that governmental meddling will result in the production of radium at a low cost. Now, as regards the first belief, we do not yet know the extent to which radium is applicable as a curative agent, but, however important it may be, there is no doubt that its relative importance to human welfare in general is grossly exaggerated. As regards the second belief, even a superficial knowledge of the subject shows that while governmental meddling may mean selling radium at a lower *price*, its production will be at a greatly increased *cost*, since in all lines of activity outside its proper functions there is no more inefficient and expensive machine than a government.

"In electric furnace practice we have analogous error which is made in the name of economy; first in attaching an exaggerated importance to the saving of the heat units generated by the electric current, and second in the inefficient and expensive machinery used for the purpose, with the result that in slightly increasing the efficiency of the furnace there is a greatly increased loss of energy.

"In attempting to realize energy economies in electric furnace practice the first consideration should be the conditions governing the cost of power, and this can best be illustrated by abstracting parts of a typical power contract:

"1. The power company agrees to deliver so many horsepower 24 hours each day and every day in the year for a period of years.

"2. In case the purchaser's requirements are greater at times than the firm horse power agreed to be taken and paid for, the power company agrees to supply such intermittent demands, but in that case the amount to be paid for is the average of the highest daily one-minute peaks occurring during the month for which the charge is made.

"3. By "firm power" is meant the amount of power agreed to be taken and paid for by the purchaser *whether or not he uses it.* By "intermittent demand" is meant the highest one-minute peak occurring during any one day.

"4. The purchaser must when possible take current equally from the three phases, but whenever it is impossible and the difference between any two phases is greater than ten per cent. of the lesser he shall pay for power as though the current taken from each phase was equal to the greatest amount actually taken from any one phase.

"5. The purchaser must always maintain a power factor as near 100 per cent. as possible, but whenever this is less than 90 per cent. the average intermittent demand shall be considered as 90 per cent. of the maximum kilovolt-amperes taken for a period of one minute each day except that the average intermittent demand shall never be considered less than the firm horse power agreed to be taken and paid for.

"The trouble with many, indeed most, experimenters who are trying to start commercial plants, and even with some plants that are running commercially, is a failure to recognize the significance of the power contract. The important consideration in the plant, so far as energy economy is concerned, is that from the time the current is thrown on 100 *per cent of it must be used* 24 *hours each day and every day in the year.*

"Instead of this consideration being the first one, it is continually neglected in the pursuit of some fad such as increased efficiency in the use of heat units or saving some waste gases or working a complicated continuous instead of a simple discontinuous process. The result is that the exaggerated importance attached to these ends, desirable in themselves, leads to load factors far below 100 per cent. or to peaks involving expensive intermittent charges or to shutting down to repair or adjust complicated machinery built in the name of efficiency, while there is never any shutting down of the power company's bills.

"A general review of electric furnace work during past years shows that a great waste has resulted from the efforts of inventors working on smelting problems because they have attempted to develop elaborate schemes for preheating furnace charges, for utilizing CO gas, to obtain preliminary reduction, etc., before they have thoroughly worked out the simple furnace problems free from efficiency devices.

"The fundamental error of this work is the attempt to force too rapidly the natural evolution from the simple to the complex. Returning to our radium analogy, we have here another case of mistaken zeal in attaining an end desirable in itself, but relatively insignificant, so that much waste results from the use of cumbersome and inefficient machinery.

"Another wasteful notion dear to the inventor is the continuous process furnace. In many cases continuous furnaces are apt to mean complicated and expensive furnaces. One of those probably costs as much as several discontinuous furnaces. If an accident happens to one of the latter there is generally another ready to go on, but with the expensive continuous furnace there often is no spare one, or if there is it takes a long time to get it tuned up to normal working order, and meanwhile the power bill is eating up profits. The exaggerated importance attached to the continuous process has done harm in another way, for it has seriously retarded the development of processes for the utilization of off-peak power. This, obviously, requires discontinuous work, which has got a bad name, thanks to the efficiency idealist.

"Incidentally, it may be mentioned that a preliminary study of the off-peak problem is distinctly encouraging, but I do not believe that it will ever be worked out until it is taken up seriously by those having power to sell rather than by the consumer.

"After making sure that the consumption of power in a furnace plant will be continuous, the next step is to keep the power at 100 per cent. of that called for in the contract. In furnaces, of which that used for making silicon carbide may be taken as the type, there is after starting a rather gradual decrease in resistance, so in order to keep the power constant some means of regulating the voltage must be used. The cheapest way of doing this is to have a step by step method in connection with the transformers, but unless the steps are very close together it is not economical. A step by step device gives a load curve that looks like the teeth of a saw, and at the end of the year the energy wasted, represented by the spaces between the teeth, will pay for apparatus giving closer voltage regulation.

"In arc furnaces we have extremely sudden changes of resistance which should be taken care of by automatic regulators. These are very commonly looked on simply as labor-saving devices, but they are just as important as savers of energy. They avoid peaks, a fruitful source of expense, and keep the balance between the three phases. In a plant with which I am acquainted the installation of automatic regulation has increased the furnace yield somewhat over 10 per cent.

"As regards the question of power factor, this is not usually troublesome, except in the case of such an apparatus as the induction furnace. In this case much may be done by the use of a suitable condenser. Thus, very satisfactory results were obtained in the case of the American Electric Furnace Company's plant in Niagara Falls by the use of a synchronous motor with over-excited field coils. It was shown that in a plant of the kind running commercially the cost of the synchronous motor would be a good investment on account of the saving in the power bills.

"As a final useful suggestion in relation to energy economies I may mention that in some cases it is possible to provide a furnace or furnaces used to absorb any power which might otherwise be wasted for one cause or another."

Power for Electric Furnace Work

A paper by **Mr. W. S. Horry**, of the Union Carbide Co., Niagara Falls, N. Y., on "Power for Electric Furnace Work" was read by title in the absence of the author, copies of the paper having been printed in advance. Mr. Horry pointed out that the electrochemical industries are rapidly outgrowing the available supply of electricity generated by the natural water powers of this country, so that in the near future they must inevitably be carried on with power generated from coal by some kind of prime mover. The extent to which the modern electric furnace requires energy is staggering. A single furnace some 16 ft. square will absorb 12,000 horse power. This amount of energy is sufficient for the light and power requirements of a small city, so it will be realized that all the available water power, great as it is, will not suffice for the needs of the electrochemical industry much longer.

It is fortunate that the production of electric power from coal has recently been simplified and cheapened. At present the cost of producing power by steam is low enough to be considered as rivaling the cost where water power is employed under the conditions that generally rule in the practice of electrochemistry.

The essentials for cheap power production from coal are close proximity to the coal mines, where plenty of water is available for condensing and where transportation facilities are adequate. The other requirements are met by the very nature of electrochemical processes. The load factor certainly will be 100 per cent and the power factor, which also enters into the costs, can be kept round 93 per cent at the switchboard even with the largest types of three-phase furnaces. Then, the first cost is kept down from the fact that it is not necessary to duplicate the generating machinery, modern boilers and turbines are quite reliable, and stoppages are remote and short and are such as not to constitute an objection for the purposes under review.

The actual prospective costs have been given by numerous contributors to other societies, such as Mr. H. M. Hobart, before the American Institute of Electrical Engineers. This author gives the investment cost as $35 per kilowatt for large powers generated at 60 cycles by steam turbine machinery and an operating cost of 0.25 cent per kilowatt hour as a minimum in cases where all conditions are favorable, and it is to be remarked that all conditions will at all times be favorable for such a plant in a properly chosen location, where electric furnaces constitute almost the entire load.

Mr. Horry thinks that Hobart's estimate is not too low or sanguine under the condition of operation of electrochemical industries. While the 25-cycle system is adequate for present requirements, the trend now seems to be to return to higher frequencies for general distribution. But large three-phase furnaces are not economically possible with a 60-cycle current. A scheme like the following may then be used:

The power of the three-phase, sixty-cycle furnace is limited. The cost of power is least when the power factor is unity. Therefore, good practice demands that this be kept high for the system as a whole and for the electric furnace in particular.

If we assume a power factor of 0.9, as measured on the high tension side of the transformers, and assume a delta voltage of 110, then the most power that a three-phase sixty-cycle furnace will take is about 2750 kilowatt, though by special design this figure can be somewhat improved. This is quite low. The modern smelting furnace is of decidedly greater capacity, to facilitate the extraction of its products.

But if this furnace be given six phases instead of three, it will take nearly double the power under the same conditions, while if twelve phases be chosen with twelve carbons in a ring at the furnace, then the power will be nearly four times that given, which would be sufficient for present requirements.

The six-phase secondary can be acquired by a mere change of the secondary connections from a three-phase transformer, and twelve phases can be similarly developed from two such transformers, one with its

primaries connected delta and the other star fashion, the secondary voltages of the two being the same. Another function is then added to the transformers to increase the number of phases, as well as to lower the voltage, and, by this means, the even power produced from all dynamic machinery is reproduced within the furnace, although, for economical transmission, only three wires are employed in the line.

While the steam turbine seems at present the only device commercially available for 20,000-h.p. electric furnaces, it will not have the entire field to itself in the electrochemical industry. The gas engine is certainly the best prime mover in the steel industry, where blast-furnace gas is available in great quantities. The reciprocating steam turbine has likewise advanced.

The actual cost of electric power derivable from a modern steam plant is not, however, the only point of view for the electrochemist. He requires coal for preparing the materials for the electric furnaces. In electrothermal work it pays to roast the ore to be smelted and it pays to dry and prepare the coal used for reducing this ore. In other processes large amounts of coal are used to concentrate the solutions produced by electrolysis. Then it happens that a plant located where coal is cheap possesses advantages even if the cost of electric power from coal should be higher than that obtainable from a hydroelectric plant situated where coal is dear.

And finally there is always before the electrochemist the possibility of extracting the valuable constituents of the coal and of running the power plant with the residue. The byproduct coke oven produces sulphate of ammonia, tar, coke and gas. The two latter are of use to him in his process, and, if the two former can be profitably sold there would be a derived revenue that would operate to lower the cost of power. The scheme looks attractive for the reason that the byproducts can be extracted only to the extent that this is profitable, while the raw coal can be served to the boilers if its treatment before use is undesirable.

Electric Furnace Regulators

Mr. Robert Turnbull, Welland, Ontario, Canada, then presented a paper on "The Thury Electric Furnace Regulator." The author discussed the advantages to be obtained from automatic regulation for the control of the current operating electric furnaces.

First, a great saving in wages, which for a three-phase furnace amounts to from 25 to 30 per cent. of the total labor employed on the furnace.

Second, a more efficient utilization of the current, resulting in maximum production, and shortening the time of the process.

Third, products of a higher and more uniform quality, owing to the steadier furnace conditions.

Fourth, the impossibility of mistakes, as the regulator always works in the proper direction and never without due reason.

The author then dealt in detail with the Thury regulator, pointing out its special advantages and describing its principle of operation. An account of this part of Mr. Turnbull's paper, together with illustrations, is reserved for our next issue.

Power in Electrolytic Refineries

The following three papers were then read by title and called up for discussion, as they had already been read before the New York section of the Society:

"The Power Problem in an Electrolytic Copper Refinery." By **Lawrence Addicks.**

"The Power Problem in the Electrolytic Deposition of Metals." By **H. E. Longwell.**

"Sources of Direct Current for Electrochemical Processes." By **F. D. Newbury.**

An account of these three papers may be found in our issue of February, 1914, pages 91 to 94.

General Discussion on Power Problems in Electrochemistry

A lively general discussion then followed.

Mr. Turnbull asked what would be a "reasonable" price for off-peak power in comparison with power used continuously 24 hours per day. There was no immediate reply from the many distinguished electrical engineers present, but, as will be seen below, Mr. Sothman gave later some interesting figures and still more characteristic advice later on.

Mr. Petinot spoke of the use of the Thury regulator and said its operation in connection with electric steel furnaces was as nearly perfect as could be desired. He had secured a regulation of load-factor as high as 97 or 98 per cent by the use of this regulator.

Mr. Lidbury thought that the different speakers had very naturally taken up the subject from their own points of view, and the papers showed that the point of view is an important factor in the consideration of any individual power problem. All speakers had shown, further, the great complications of their own particular phases of their power problem due to the very varied nature of electrochemical operations, in respect of size, the relative importance of power costs and the importance of other considerations that may enter into the problem. The horsepower used per employee varies in different electrochemical industries between 20 and 100 h.p. On account of this variety of conditions it is very dangerous to make generalizations without stating clearly the limiting condition. Mr. Lidbury finally said that there are enough electrochemical problems to solve, and operating engineers favor, above everything else, simplicity. He told the experience of an engineer in a concern where an elaborate "efficiency system" had been installed. When it had been in operation for a year and the efficiency expert called and asked how his efficiency system worked he was told it worked fine. "And how about business?" "Well, we have no time to attend to business now."

Mr. Hansen called attention to the fact that in general in arc furnaces, operating at low load, there is considerable wave distortion. As the load increases the wave distortion becomes less and less important.

Dr. Steinmetz said that wave distortion had been studied carefully 20 years ago in the case of the series arc-lighting system. The best advice that can be given on wave distortion in connection with electric furnaces is to get rid of it as soon as possible. The best means is reactance. If the power-factor is reduced by reactance we lower the wave-shape distortion and thereby eliminate the reduction of power-factor due to wave distortion. That means that where attempts are made to get as high power-factor as possible by cutting down all the reactance in the operation of the furnace the results have very often been disappointing. The mistake is made in most furnace operations to attempt to get a low reactance. Besides reducing wave distortion, reactances have the advantage that they prevent power fluctuations and balance the load on a three-phase system.

Mr. Lincoln, president-elect of the American Institute of Electrical Engineers, said that the calculation of the power-factor from the oscillograph record gives more correct results than a power-factor meter. If the current wave is of the same shape as the voltage wave, the power-factor meter gives the true power-factor, but if the current wave and the voltage wave are not of the same shape the power-factor meter does

not give the true power-factor, and the latter must be determined in some other way. Wherever an arc is present, the current wave is not the same as the voltage wave. Mr. Lincoln thought that Hobart's figures for the cost of power from steam related to ideal conditions and could hardly be realized in practice.

Mr. Hansen explained that he had determined the power factor from oscillographic records and gave a very interesting account of the trouble experienced when the basic slag of an electric furnace evaporates and reacts with the silica roof.

Mr. Sothman thought it was agreed that the question of power is one of the most important in the electrochemical industry. In replying to Mr. Turnbull's former question he said he knew of Canadian contracts for power where the fundamental rate was $28.50 for power 24 hours a day for 365 days a year. If the consumer would permit shutting off 20 per cent of the power during the four winter months in the year for one and one-half hours per day that power could be had for $24, which is a reduction on the total power bill of about 22 per cent. In other cases reduction as high as 34 per cent had been made if it was off-peak power. If the amount of power per employee is relatively very large it pays to buy off-peak power. If there are ten men working on a certain process and 1000 horsepower is being used and off-peak power can be purchased 25 per cent cheaper it is more economical to buy the off-peak power, and lay the men off for an hour or two, provided the process is not in any way interfered with as to the final results. But in speaking of the cost of power it is very important to state clearly how the power is measured and where it is measured, and to look for the small gifts or no-gifts mentioned in the power contract. "Gentlemen, when you are about to sign a power contract open your eyes—open your eyes twice."

Dr. Hering, in commenting on Dr. Steinmetz's paper as eminently fair and clear, recommended it to the perusal of the power engineers, who seemed to be very slow to understand that it is to their interest to sell valley power quite cheaply.

Policy of the Bureau of Mines

As the last subject of the Thursday morning session a letter by the Director of the Bureau of Mines, Dr. **J. A. Holmes**, dated April 15 and addressed to the President of the American Electrochemical Society, Dr. E. F. Roeber, was read by the Secretary, Dr. J. W. Richards. It is exceedingly interesting in defining the policy of the Bureau. Dr. Holmes' letter reads as follows:

"I regret exceedingly to find that important administrative matters in connection with the mine safety work of the Bureau will make it impossible for me to attend the meeting of the Electrochemical Society in New York tomorrow as I had intended doing; and also that these matters will prevent my being with the members of the Society during the steamer excursion Friday.

"I regret not being able to attend this meeting of the Society all the more for the reason that I anticipate a few of its members may have been misled by recent press dispatches as to the nature and extent of some of the Bureau's proposed work, especially in relation to the radium industry, and I might have been able to say something to correct misapprehensions along this line.

"In connection with the subjects which the Bureau is authorized to investigate it acts for the Government of the United States in the same way that any engineer or chemist may act for a private corporation by which he may be employed.

"Thus, for example, in relation to the radium industry, about which the press has of late had a good deal to say, the Government needs for use and especially for researches in its hospitals located in different parts of the country under the Public Health Service and under the Army and Navy, a certain quantity of radium, which at the prevailing market price will cost between $3,000,000 and $4,000,000. The chemists and mining engineers of the Bureau of Mines in a study of the radium-bearing ores on the public lands with a view to efficient development and the prevention of unnecessary waste, have developed methods of concentration and treatment through the use of which they estimate that the radium needed by the Government can be produced from ores now belonging to the Government at a cost considerably less than half of the existing market price. Other parties have discussed the subject and have framed legislation with a view to enlarging the scope of these operations; but the accredited representatives of the Bureau of Mines have neither planned or advised the extension of this work beyond the Government's own needs.

"Under somewhat similar circumstances a few years ago the Government was unable to purchase at what was considered a reasonable price cement for the construction of the Roosevelt Dam under the Reclamation Service. Under the circumstances a cement plant was erected on the ground, and an adequate supply of cement was manufactured and the dam constructed by the Government at a cost of nearly $1,000,000 less than the original bids by private parties. Nevertheless, no one recommends or expects the Government to go into the general cement manufacturing business.

"Insofar as its general work is concerned the policy and purpose of the Bureau of Mines is to help, and certainly not in any way to hinder, the professional work of private experts or the operations of private persons or corporations. Our work relates primarily to the public welfare, especially with relation to safeguarding the lives of employees, the prevention of unnecessary waste of resources, and the general advancement of the mining, metallurgical and other mineral industries. It is in the performance of this general public duty and in the carrying out of this general public purpose that I should be glad to have, and I feel sure the Bureau of Mines will receive, the hearty co-operation of the members of the Electrochemical Society."

A complimentary luncheon was served at 1 o'clock.

Electrolytic Flames

After lunch had been taken in the social rooms of The Chemists' Club, the afternoon session began sharply at 2 o'clock with a most interesting experimental lecture by Professor **Wilder D. Bancroft**, of Cornell University, on electrolytic flames.

He called attention to the fact that metals do not give the same flame color for all of their salts. For example, sodium salts usually give a spectrum, but do not in a hydrogen-chlorine flame. There is probably metallic vapor in some flames, which tends to the dissociation of exothermic compounds in flame. This was proved by the precipitation of metallic mirrors from flames striking a water-cooled porcelain tube. This was illustrated by producing in a Bunsen flame mirrors of copper, silver, bismuth, antimony, arsenic, lead, tin cadmium and zinc. Molybdenum and tungsten salts do not give mirrors in the Bunsen flame, but fine mirrors of these metals were obtained from the oxy-hydrogen flame. Even sulphur can be thus precipitated on cold porcelain from sulphur dioxide, and red phosphorus from phosphorus compound.

We thus have evidence that many reactions take place in flames, and different reactions may cause the emission of different colors. For example, copper changed to cuprous ions in flame gives a green color; cuprous salt changed to cupric salt colors the flame blue; cuprous ion changed to cuprous salt colors the flame red. Tin changed to stannous salt gives carmine, but stannous salt to stannic salt gives green.

Many rapidly occurring chemical reactions emit light, and this is not confined to reactions taking place at high temperatures. Thus phosphorus oxidized by hydrogen peroxide gives colored phosphorescent light. Bromine oxidized by pyrogallol gives pale orange light. Mercury heated in bromine flame vaporizes at a very low temperature in an orange flame. This very clever experiment was beautifully performed.

W. D. BANCROFT

Finally, the oxidation of bromine at an anode in potassium bromide solution, with a current voltage of only two volts was shown to give an orange-yellow glow at ordinary temperature.

Professor Bancroft closed by stating that as a working hypothesis it appears that the conversion of the energy of the chemical reaction in a light increases as the temperature is lowered, and vice versa, thus explaining the common occurrence of luminescence at very low temperature as observed by Dewar.

Professor Bancroft's lecture was discussed by Messrs. Hambuechen, Tucker, Northrup and Whitney.

Electric Steel Castings

Mr. C. A. Hansen, of the General Electric Company, then presented in abstract two papers on the electric furnace in the steel foundry, one by himself, the other by Mr. E. B. Clark, president of the Buchanan Electric Steel Company of Buchanan, Mich.

Mr. **C. A. Hansen** gave in his paper the results obtained with a 2-ton three-phase arc furnace in use since 1911 in the foundry of the Treadwell Engineering Company at Easton, Pa., which had taken over the work of an old crucible steel castings plant, making light section castings.

The cost of melted metal from the electric furnace was found to be somewhat less than one-half that of the old crucible furnace plant when the latter was using oil at 2½ cents per gallon. Since the advance in the price of oil has added $6.00 to $7.00 more to the cost per ton of molten crucible steel, the possibilities of saving in costs is readily apparent.

So far as the product is concerned, the most striking differences are not found in comparing electric and crucible steels of similar compositions. If any differences exist between such steels, they are negligible in importance, as repeated tests have shown.

Electric steel castings are usually made in lower carbons than it is possible to make from even clay-lined crucibles. In the latter it is perfectly possible to melt 0.20 carbon steel, but it is not possible to run the 0.20 carbon product regularly into light-section castings. As a result, 0.30 to 0.40 carbon castings are the usual output of the crucible steel foundry, and all castings which require machining must be annealed.

With the electric furnace, furnace maintenance costs increase rapidly as the carbon content of the product is brought down, and, quite contrary to current opinion, it is not economical to turn out 0.10 carbon steel castings, although it is perfectly possible to do so.

It is, however, economically practicable to turn out 0.20 carbon castings, and such castings can be machined easily without annealing. There is little question that all castings, whether 0.20 carbon or 0.30 carbon, can be improved by annealing, but the American attitude seems to be against the expense of annealing where annealing can be avoided.

Many have suggested charging molten cupola metal directly into the electric furnace for refining. In several such cases of which the author knows, the power consumption per ton of output was greater for the cupola metal charge than for the cold scrap charge; the original cost of the cupola metal was in the neighborhood of $18 per ton, as compared with $12 per ton for the regular cold charge, and the cost of furnacing was likewise higher for the cupola metal charge. The economy incident to heating the furnace with auxiliary fuel-burning apparatus may interest those who charge molten metal into electric furnaces, but the interest attaches rather to the prevention of skulled furnace bottoms than to a direct saving in electric energy. Heating the furnace and charge to a good red heat by means of oil burners (with oil at 2½ cents per gallon) increased the cost $1 per ton over the regular practice of all-electric heating. Keeping the furnace hot over night by means of either oil or electric energy was found not to materially decrease maintenance costs, and it did increase the cost of production. These items above refer to power supply at approximately 1 cent per kw-hour.

Much stress has been laid on the economy attaching to continuous operation of the electric furnace as compared with mere day-shift operation. So far as costs go for the molten steel, it is true that continuous operation means 10-15 per cent saving over intermittent operation. Very little has, however, been said regarding the relative efficiencies of day and night work in the other departments of the foundry, nor has it been well impressed upon the mind of the average investigator of electric steel problems that one can easily lose many times the 10-15 per cent saving in molten metal costs in the decreased efficiency of the night shifts on the molding floor, cleaning room, etc.

Claims are being made that 10 to 12 heats from cold scrap can be taken from one electric furnace in 24 hours. Possibly they can, but the furnace will have to be rebuilt at least three times each week.

These and other considerations have led to the practice, now established at Easton, of operating the foundry on day shift only, charging a good quality of steel scrap, enough pig and ore being added to keep the charge off the furnace bottom, and casting steel of around 0.20 carbon, unless otherwise specified.

The furnace plant has been operated on a one-heat-per-day basis, requiring 7 to 7½ hours to turn out its charge from the cold furnace. Power consumption at furnace transformer primary terminals has, in that case, averaged 1050 kw-hours per 2000 lb. (909 kg) steel in the ladle.

The furnace has been operated also on a two-heat-per-day and three-heat-per-day basis, when business conditions warranted. The second and third heats, having the advantage of being started off in a hot furnace, are finished in 4½ hours, at a current consumption of 630 to 640 kw-hours per ton. Even with the three heats per day, no steel is poured outside of the regular day shift. Two men start the furnace

shortly after midnight, and steel is poured at 7.15 a. m., 11.45 a. m. and at 4.30 p. m. The uncertainties attaching to pouring on schedule time are not as great as they are with either open-hearth or crucible furnaces.

The load curve for the furnace here considered is smoother and of higher power-factor than the load of similar magnitude used in the shops of the Treadwell company where the products of the steel and iron foundries are machined.

Mr. Treadwell has recently sent the following additional data concerning his furnace:

Average number of heats per week	15
Average weight per heat	4600 lb.
Average power consumption per 2000 lb	900 kw-hour
Average repair costs per 2000 lb	$2.50
Average electrode costs per 2000 lb	$2.50
Average weight castings made	9 lb.
Ratio of cleaned castings, risers, etc., to charged weight,	92-95 per cent
Ratio of finished castings to charged weight,	approximately 60 per cent

The furnace lining is repaired after 35 heats.

Mr. Treadwell is a firm believer in pouring extremely hot steels, and this fact is reflected in the high maintenance costs and in a rather high power-consumption.

A similar furnace, of which Mr. Hansen has accurate records, shows costs as follows:

Power consumption per 2000 lb	725 kw-hour
Repair costs per 2000 lb	$1.30
Electrode costs per 2000 lb	$2.15

The latter furnace is pouring somewhat colder metal into castings of 15 lb. average weight, and repairs to the furnace lining are made after 8 to 10 weeks' operation on the same basis of fifteen heats per week. In the latter case the repair charges include upkeep of the bottom-pour ladles used, and this is believed to be also the case with Mr. Treadwell's figure.

Electric Furnaces for Steel Making

Mr. E. B. Clark, in his paper on this subject, says that the intending user of an electric furnace wishes dependable answers to two questions:

First.—How will an electric furnace compare with some other apparatus for producing or refining steel as to quality of output and cost of operation?

Second.—Assuming the wisdom of an electric furnace installation, what is the best type of furnace, and what size of unit is proper?

The author compares the electric furnace, the crucible furnace, the Tropenas converter, and the open-hearth furnace.

The crucible furnace enables one to make accurate alloy mixtures of high quality without contamination from gases or furnace linings. Practically no refining can be done and therefore high-grade materials must be used for the mixture. By the law of supply and demand, the price of pure materials for use in crucible furnaces will be higher where the crucible process is employed to a considerable extent. The electric furnace will produce steel of the same degree of purity as a crucible furnace, and the possibility of refining in an electric furnace makes possible the use of less pure materials. This is an advantage for the electric furnace and, at the same time, an advantage for the crucible furnace, because the demand for the high grade materials necessary in the crucible process is reduced by each additional electric furnace installation and therefore the price of the charge for the crucible furnace is reduced. This is especially true as applied to the small crucible furnaces used in foundry practice, which require low-phosphorus steel punchings for their successful operation.

The small Bessemer converter, or Tropenas vessel, is capable of producing hot steel in small units quickly. It does not permit of refining, however, and therefore, necessitates the use of low phosphorus and low sulphur pig iron which must be pre-melted in a cupola, using high-grade coke. The losses are severe and the steel is not free from oxides and occluded gases. The electric furnace will produce steel just as hot as the small Bessemer vessel, but free from oxides and occluded gases. However the electric furnace requires scrap for charging rather than pig iron, so if only pig iron is available at commercially desirable figures, the pig must be converted into steel before charging into the electric furnace.

The open-hearth furnace will produce from pig and scrap, steel of a fairly high degree of purity and of fairly high temperature. The electric furnace will do the same thing (except that the use of a large percentage of pig is not desirable) and is capable of producing purer and hotter steel than is the open-hearth under usual operating conditions.

Summarizing these general observations, it may be said that for the alloying of steels the electric furnace offers nothing that the crucible furnace does not; for the production of a very hot steel an electric furnace offers nothing that the Bessemer converter does not; and metallurgically speaking, the electric furnace offers nothing that the open-hearth does not. It is a fact, however, and this is the important fact, that the electric furnace combines in itself certain advantages of all three of the other processes mentioned. On the other hand, it is seldom that one wishes to secure the advantages of all these other three processes combined in one.

For the electric furnace the cost of power is not of supreme importance. Experience is more important. The electric furnace is a more delicate apparatus than any of the other three furnaces mentioned. Electric furnace operation has not yet been reduced to standard practice. Melters familiar with its operation are scarce and difficult to find.

Mr. Clark then gives an account of his experience with two electric steel furnace types. One is a 1 to 1½-ton furnace of the Stassano surface-arc type, the other a 5-ton furnace of the Heroult submerged-arc type.

"To summarize our views upon the relative merits of the two types of furnaces, as based upon our own experience, I would say that we have found the surface-arc type to be a much better furnace than its critics would have one believe. On the other hand, we have found the submerged-arc type better for our purposes because of its larger capacity and lower cost of operation. It would not be fair, however, to ascribe the lower costs entirely to its type, for the capacity of a unit certainly has much to do with the lower cost. Where a foundry is, like ours, entirely dependent for its supply of hot metal upon the electric furnace, this type is better by reason of less necessity for lining repairs."

"In conclusion, I wish to reiterate my statement that an intending user of an electric furnace may expect to learn much more about the furnace by his experience after he gets it than by the statements of someone who wishes to sell him a furnace."

Discussion on Electric Steel

The two papers by Mr. Hansen and Mr. Clark elicited quite a lively discussion.

Mr. H. D. Hibbard said the two papers are valuable as an account of actual practice. He thought that operators of electric steel furnaces often use too high a temperature.

Mr. Ernest Humbert protested against the conclud-

ing remarks in Mr. Clark's paper as a reflection on sellers of electric furnaces. Electric-furnace steel is fully equal to the best crucible steel. While good steel castings can be made in crucibles, it is not possible to make them low in carbon. As to the scarcity of skilled electric melters, he had himself trained quite a number of men reliably in a short time in electric-furnace operation. It takes quite some time to produce a good open-hearth melter. He thought that an advantage of the Heroult type over the Stassano type is that in the former the roof is subjected to less heat by radiation.

Dr. K. G. Frank gave figures on the progress of the electric steel furnace in Europe, especially in Germany and Austria, which has been much more rapid and satisfactory than in this country. He thought American steel makers had not attacked the electric steel furnace problems with the same thoroughness and attention to detail.

Mr. Henry Hess spoke of his satisfactory experience with a Stassano furnace in making steel castings during several months and, contrary to Mr. Humbert's statement, they have had no trouble at all with their magnesite roof.

Mr. C. A. Hansen thought that Mr. Clark after having operated a Stassano furnace had applied his experience obtained with the latter to the operation of a Heroult furnace. This is a mistake as there is an essential difference between the two types. A characteristic feature of the Stassano furnace is the independence of slag. The Heroult furnace is not independent of the slag and it is important to avoid fluctuations of power supply.

Dr. J. W. Richards said that electric-furnace roofs are not always of silica as had been intimated. Stassano uses a magnesite roof. Aluminium nitride may also be considered as a suitable material. He agreed with Dr. Frank that the more rapid progress of the electric furnace in Europe is due to the greater patience exercised there.

Dr. C. G. Schluederberg said that at a recent visit to the Latrobe Steel Castings Company he had seen several runs with manganese steel in a Heroult furnace and had been impressed with the very uniform load curve.

Mr. C. A. Hansen remarked that crucible steel castings are not all now what they used to be. They are not always dead melted. The electric furnace has one important advantage for large production, that is the possibility of knowing exactly what you are pouring before you pour. With converter and crucible steel castings you must rely on guess work and this results in nonuniform metal. The main thing in a new electric-furnace plant is to establish a practice. The trouble is now that high-priced men accept positions as electric-furnace melters at a low salary simply to get the experience, and when they get it they leave and the training of a new melter has to begin all over again.

Mr. E. L. Crosby said that the Detroit Edison Company had made a special rate for electric steel at ¾ cent per kw-hour or less, according to the hours in which the current is used.

Mr. F. A. Lidbury remarked the electric steel furnace was an example of the possibility of using the electric energy of central stations during off-peak hours.

Mr. C. A. Hansen said from his experience that with one heat a day it cost $80 per ton to make a ½-ton heat and $27 per ton to make a 15-ton heat, while with two heats per day the cost for a ½-ton heat is $60 per ton and $19 per ton for a 15-ton heat.

Mr. R. Turnbull thought the figures for the ½-ton heats were high. Mr. W. McA. Johnson suggested Mr. Hansen's salary might be in the overhead charges.

Mr. E. F. Cone emphasized the physical and chemical superiority of electric steel castings, due to the greater refining possibilities of the electric furnace. The chemical purity is greater, the tensile strength and elastic ratio are improved, and not only the static but the dynamic properties of the steel are better.

Mr. Hess thought that steels of exactly the same composition would have the same properties and that it would not matter whether the heat had been applied electrically or otherwise.

Mr. Hansen said that comparative tests of electric steel and open-hearth steel at Schenectady had shown no essential difference in properties.

Dr. Richards stated that the refining action of the electric steel furnace must result in superior castings and Mr. Cone added that it was self-evident that the purer a steel the better its qualities, and that the higher purity of electric furnace steel could not be questioned.

Mr. Wm. D. Mainwaring said that steel must be mixed thoroughly and the time factor must be taken into consideration. In his 15 years' experience in steel making with all kinds of furnaces he had seen some of the poorest steel made in electric furnaces and had seen some of the best made in that furnace. It is necessary to work steel right in all kinds of furnaces.

Mr. Hibbard thought that the hearth on which the steel is made should be taken into consideration. In the crucible it is graphite, in the open-hearth iron oxide, while the electric furnace has a basic bottom.

Metallurgy of Zinc

The following two papers were read by title only as they had already been read before the New York Section of the Society; long abstracts of the same were given on pages 677 and 678 of our Vol. XI (December, 1913):

"Improvements in the Metallurgy of Zinc," by **G. C. Stone.**

"Electric Zinc Smelting," by **W. R. Ingalls.**

Contrary to expectations there was no discussion.

Advantages of Southeastern Alaska for Hydroelectrochemical Industries

An article by Mr. W. P. Lass called attention to the natural resources of Southeastern Alaska for that class of industry which requires cheap hydroelectric power. The unsettled policy of the Government regarding the exploitation of Alaska has hindered development in that country; but more recently the Government's attitude is more clearly defined. It is impossible to get perpetual title to water rights, but 50-year permits for the use of water, subject to renewal, may be obtained by the payment of nominal fees not exceeding $1 per horsepower year.

Southeastern Alaska presents a network of navigable bays and inlets with shores rising to an altitude of two or three thousand feet. Lakes situated high in the mountains afford an easy means of conserving precipitation and equalizing flow.

At the present time only a very few of the available waterpower sites have been developed. One of these, the Speel River project, can develop all-year power to the extent of 1000 hp. The cost of generating is estimated at not to exceed $5 per horsepower year, and the cost of installation at less than $50 per horsepower.

The country has economic deposits of such raw

materials as limestone, marble, gypsum, silica and pyrites. There is also high-grade semi-bituminous and anthracite coal, as well as producing oil wells and a refinery. There are known deposits of iron ores in Alaska, and the electric production of pig iron is a possible industry on account of the availability of cheap power and the abundance of charcoal.

The author believes that Alaska offers the same advantages as Norway for the establishment of electrochemical industries, with the exception of the cost of labor, which is $3 to $4 per day. Among the manufactures which the author considers possible in Alaska are electric smelting of iron and non-ferrous minerals, the production of sulphuric and nitric acids to be used in the manufacture of wood pulp, paper, and phosphate fertilizers. Cyanide and powder are also in demand and can be manufactured in Alaska for use throughout the West.

Another possible industry is the manufacture of potash salts from kelp.

Leaching Copper Ores at Chuquicamata, Chile

The feature of the Saturday morning session held in Earl Hall, Columbia University, was an illustrated lecture by Mr. **E. A. Cappelen Smith**, consulting engineer with M. Guggenheim Sons, on the progress of experimental work in the treatment of oxidized copper ores from Chuquicamata, Chile. The investigations have been carried out under the direction of Mr. Smith during the past year on a large scale for the purpose of determining the metallurgical details of the 10,000-tons-a-day plant to be erected in Chile.

E. A. CAPPELEN SMITH

In view of the importance of this lecture we print it in full on page 291 of this issue and also comment on it in our editorial pages.

Mr. Smith exhibited the fused magnetite electrodes used as anodes and originally invented by the German Griesheim Company for their use in their cells for electrolysis of brine.

The lecture was discussed by Messrs. Richards, Addicks and Lidbury.

The Hydroelectrolytic Treatment of Copper Ores

This paper by Mr. **Robert R. Goodrich** gives a brief summary of hydro-electrometallurgical copper processes and a review of the literature on that subject. The author classifies the hydro-electrometallurgical process into two groups: First, purely chemical methods such as alkali, sulphite, sulphate and chloride processes; and second, electrolytic methods such as sulphate and chloride processes. The paper consists mainly of brief descriptions of different processes according to above classification.

Leaching of Copper Tailings

A paper by Dr. **Rudolf Gahl** gives the results of some leaching tests made at Morenci, Ariz., in connection with the concentrating plant of the Detroit Copper Company. The author calls attention to the changing sentiment among the engineers regarding the feasibility of leaching copper ores. The water-concentration processes have not given satisfactory recoveries of metal, particularly in those cases where there is a mixture of sulphide and oxidized copper minerals.

The loss of the latter is very high, particularly in slime tailings.

The author advocates the counter-current continuous decantation process, as developed in the cyanide industry, as the best method of leaching and washing copper slimes.

The work at Morenci resulted in the recovery of 60 per cent of the copper contained in the slime tailings, this recovery representing the copper existing in the oxidized state. A higher extraction could have been obtained by using ferric sulphate in connection with sulphuric acid.

The probable operating costs of a leaching plant for slime tailings were calculated on the basis of the experiments, with a certain margin for safety. They are represented below. The tailings slime being ordinarily a waste-product was considered not to cost anything.

Probable Cost of Leaching Tailings Slime per Pound of Copper Delivered at New York

3.50 lb. acid, at $10 per ton H_2SO_4	1.75c.
1.50 lb. of scrap iron, at $19 per ton	1.43c.
Power	0.25c.
Labor and repairs	1.00c.
Smelting, refining, transportation of Cu, including losses in smelting, etc	2.00c.
Interest and depreciation of plant	1.00c.
Total	7.43c.

The figures are based on conditions prevailing at Morenci, Ariz., where the tests were made. Owing to the location of this mining camp freight rates are rather high.

Since making the leaching tests the flotation process has been applied to the same material with considerable success in saving the sulphide portion. The author concludes, therefore, that for certain classes of copper ores the combination of a flotation and a leaching process consitutes a form of treatment that would be difficult to surpass.

Metal Inventory in an Electrolytic Copper Refinery

A paper by Mr. **Ralph W. Deacon** giving in complete detail the methods used in an operating plant for a number of years, in taking regular inventories of metal. The taking of the inventory is divided into sections, each operating department accounting for all metal on hand at the inventory moment or "cut off."

"Cut offs are made between each department and between sub-units within each department, and for materials going in each direction, and each department or sub-unit is held responsible for the proper handling of the 'cut off' of both incoming and outgoing material, with especial emphasis placed on the incoming 'cut off.' That is, a department is not relieved of the responsibility of seeing that the 'cut off' on outgoing materials is correct, but the initiative in this respect is expected to be taken by the department receiving the material, i. e., the incoming 'cut off.' This has so worked out that any trouble due to mixup in proper 'cut offs' is entirely unknown."

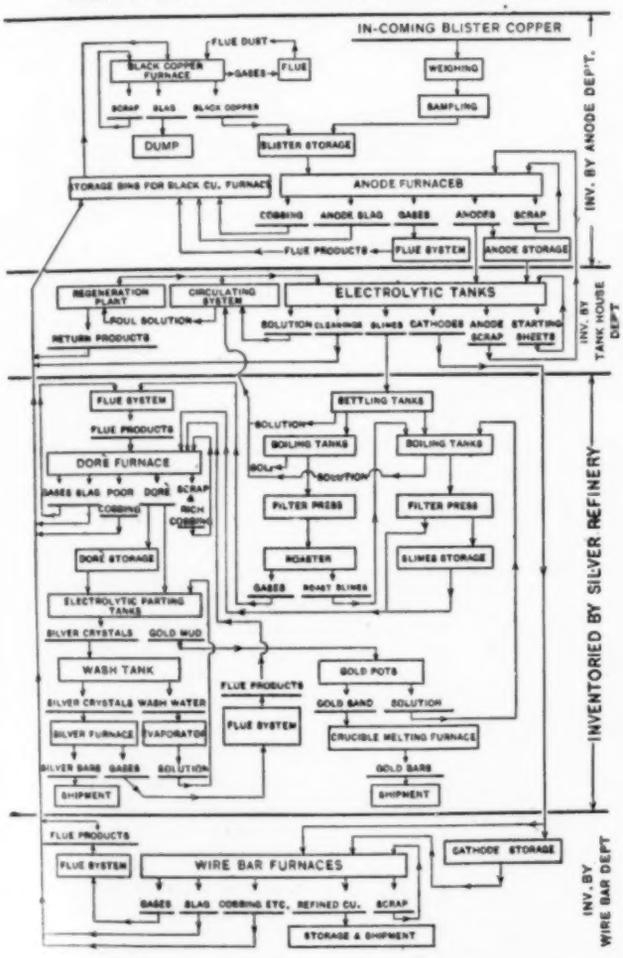
There are four separate inventories grouped, as shown on page 339. "In general the anode department accounts for all metals between the stages of arrival at the plant and delivery in anode form to the tank house. The latter then accounts from this point to that of delivery of cathode copper to slimes. The

wire-bar department accounts from the stage of cathodes received to refined copper shipped, and the silver refining department, from slimes received to fine gold and silver shipped."

Electrolytic Zinc

A paper by Professor **Jos. W. Richards** on the electrolytic deposition of zinc was read by title as it has been already presented before the New York Section

FLOW SHEET OF ELECTROLYTIC COPPER REFINERY



DEPARTMENT INVENTORY OF COPPER REFINERY

of the Society. It is a review of a recent lecture by Dr. Victor Engelhardt on the subject, with critical remarks by the author.

Addition Agents in the Deposition of Zinc from Zinc Sulphate Solution

A paper by Messrs. **O. P. Watts** and **A. C. Shape** gives the results of experiments with forty-two different organic substances in a zinc-plating solution. The electrolyte was made by adding an excess of zinc to dilute sulphuric acid. The solution had an acid reaction and contained 25 per cent of $ZnSO_4.7H_2O$. The amount of organic substance added was 1 gram per liter. The solutions were electrolyzed for two hours at about 22 deg. C., with a zinc anode and an iron cathode, at a current density of about 10 amperes per square foot (1.1 amperes per sq. dm.). For comparison, the well-known Meaker galvanizing solution was electrolyzed under similar conditions. The majority of the substances added had an injurious rather than a beneficial effect upon the deposit. The most common defect was the production of vertical grooves or striations.

The general result of these preliminary experiments was the discovery of three promising addition agents for the deposition of zinc from a solution of zinc sulphate, namely, eikonogen, pyrogallol and betanaphthol.

Electrodeposition of Cadmium

Two papers, by Professor **Frank C. Mathers,** and Mr. **Hugh M. Marble, of** Indiana University, deal with the electrodeposition of cadmium.

The first paper gives a review of the existing literature on the electrodeposition of cadmium and is divided into four chapters, dealing with cadmium salts of inorganic acids, ammoniacal solutions, cadmium salts of organic acids, commercial plating and refining respectively. In almost all cases crystalline rough deposits were obtained.

In the second paper the authors give the results of their own original experimental work in which an attempt was made to determine what salts of cadmium are best suited for giving smooth, non-crystalline deposits. Baths containing equivalent weights of the different salts of cadmium were electrolyzed under the same conditions. The cathodes from the ammoniacal and the alkaline tartrate baths were hopelessly spongy. The deposits from the acetate, bromide, iodide, sulphate, phosphate and chloride solutions were rough and crystalline. Many experiments were tried with the chloride solutions. A bath containing 4 per cent cadmium as the chloride, 10 per cent ammonium chloride, 5 per cent hydrochloric acid (by volume) and 0.1 per cent peptone gave a fairly smooth, finely crystalline deposit. A bath of the same composition as that just given, with the addition of 10 per cent ferric chloride, gave a much better deposit. Manganese, aluminum or chromium chlorides did not improve the deposit in the same way that the iron did. None of these deposits were equal to those described below. In the few experiments that were tried with the bromide and iodide solutions, the deposits were more crystalline and rough than with the chloride baths.

Fluoride, fluosilicate, fluoborate or perchlorate solutions containing 4 per cent cadmium, with 0.5-5 per cent free acid and 0.2 gm. peptone, glue or phloridizin, or 4 drops of clove oil, gave excellent, smooth deposits. Not all of these addition substances were tried with all of the above cadmium salts, but in all cases where they were tried excellent deposits were obtained. Sometimes spongy places or spots were formed upon the cathodes. Some rough projections also gradually formed on some of the cathodes. It is thought that these rough places were produced by particles of slime, which became detached from the anodes in spite of the wrappings of filter paper. Amalgamation of the anodes completely prevented slime from becoming detached, but this scheme was tried only in the quantitative experiments.

These experiments again demonstrate the value of "addition agents," since smooth deposits of cadmium could not be obtained without their use. The same addition substances—clove oil, glue, peptone and phloridizin—which were found to give good lead deposits are the only valuable ones for cadmium deposition.

Cadmium is much more difficult to obtain in a smooth condition than lead.

There was a gradual loss of free acid in the baths, due to chemical solution of the anode. This had little effect upon the deposits, since only a little free acid is required in the solutions.

Electrodeposition of Nickel

A paper by Dr. **C. W. Bennett**, Mr. **H. C. Kenny** and Mr. **R. P. Duggliss**, of Cornell University, on the electrodeposition of nickel reaches the following results:

A good deposit of nickel may be obtained from the double sulphate if the solution at the surface of the cathode is kept alkaline.

The efficiency is dependent upon the degree of alkalinity of the cathode film.

The efficiency can be started high and maintained high by adding a definite amount of ammonium hydroxide to the solution.

The alkaline solution film at the cathode may be disturbed and the efficiency of deposition decreased by stirring the solution vigorously.

Since alkalinity is necessary for good efficiency, it is very probable that in acid solutions nickel is deposited only when impoverishment of the hydrogen ions has caused the solution to become alkaline and given the conditions under which nickel may deposit.

The iron content of a deposit formed on a rotating cathode is greater than that formed on a stationary electrode. This may be due to mechanical occlusions.

The iron content of the anode does not materially affect the efficiency.

Electrolytic Deposition of Brass

A paper by Dr. **C. W. Bennett** and Mr. **A. W. Davison**, of Cornell University, on the electrolytic deposition of brass on a rotating cathode, reaches the following conclusions:

Measurements were made of the voltages required to deposit copper and zinc from a number of solutions with rotating cathodes, the voltages being measured against an oxygen electrode. Those solutions giving similar curves were studied with a view to obtaining a good deposit of brass. A brass was not obtained in any case, except from the cyanide solution.

The deposition of brass from cyanide solution is probably due to two factors: First, the tendency for the potentials of copper and zinc to become the same in the cyanide solution, and, second, the increase in the potential of the more noble metal by impoverishment. The latter factor is practically eliminated by using the rapidly rotating cathode.

A satisfactory brass has not been deposited from the cyanide solution on the rotating cathode. The brittleness of the alloy is probably due to occluded impurities. Hydrogen was removed from the alloy by heating in alkali. The disturbing factor probably arises from the cyanide itself, which it seems impossible to eliminate.

The effect of impoverishment has been shown by showing that a brass may be obtained up to a limiting speed of rotation of the cathode, beyond which zinc alone is deposited.

The metal ratio of copper to zinc in solutions for the deposition of a brass varies not only with variations of free cyanide, but also with the rate of rotation of the cathode.

New Method for the Determination of Free Cyanide In Electroplating Solutions

A paper by Mr. **Gustave E. F. Lundell** proposes a new method for the determination of free cyanide.

"Briefly stated, the new method consists in titrating an ammoniacal cyanide solution containing a small quantity of dimethyl glyoxime, with standard nickel-ammonium sulphate solution until a permanent red precipitate is produced. The reactions involved are expressed by the equations:

$$NiSO_4 + 4KCN = K_2Ni(CN)_4 + K_2SO_4$$
$$NiSO_4 + 2C_4H_8N_2O_2 = Ni(C_4H_7N_2O_2)_2 + H_2SO_4$$
$$H_2SO_4 + 2NH_4OH = (NH_4)_2SO_4 + H_2O$$

"No permanent red precipitate of nickel dimethyl glyoxime is formed until all of the free cyanide has been used up in the reaction expressed by the first equation. Free sulphuric acid hinders the precipitation of nickel dimethyl glyoxime, hence the ammoniacal cyanide solution."

The solutions required are a standard solution containing 15.3 grams of nickel-ammonium sulphate, in water containing 5 cc. concentrated sulphuric acid, diluted to 1 liter and a dimethyl glyoxime solution containing 8.9 grams of dimethyl glyoxime in 1 liter of 95 per cent alcohol.

The method of analysis is as follows: A measured volume of the electroplating solution is diluted to 100 cc., treated with 1 cc. of ammonium hydroxide, 1 cc. of the dimethyl glyoxime solution, and then titrated to a permanent red precipitate with the standard nickel-ammonium sulphate solution. The color play toward the end of the reaction resembles that seen in the titration of an alkaline methyl-orange solution with an acid solution. For the sake of accuracy, and also convenience, the volume of electroplating solution taken should contain from 0.2 to 0.5 gram of free cyanide.

The author states that the new method is more rapid and accurate than other methods and has greater freedom from interferences.

Electric Conduction at High Temperatures

The session of Saturday afternoon, held in the lecture room of the School of Mines, Columbia University, was opened by a lecture, illustrated by many lantern slides, by Dr. **Edwin F. Northrup**, of Princeton University, on "Electric Conduction at High Temperature and How to Measure It."

The older physics recognized matter and energy as the two objective realities but the newer physics adds electricity as a third objective reality. The transference from one point in space to another of unelectrified matter, or of electromagnetic energy forms no part of the problem of electric conduction which is confined to the transference of electricity.

E. F. NORTHRUP

The problem of electricity must answer the two questions: (a) Why do different materials have a different electrical conductivity at the same temperature? and (b) Why does the electrical conductivity of a given substance change when the temperature changes?

These questions can only be answered in a satisfactory way, without unwarrantable extrapolation, by examining the experimental facts of conduction over a very wide range of temperature. By far the greatest number of facts of conduction have been examined in the temperature range, 0 deg. to 100 deg. C., which is but about 2½ per cent of the temperature range which has been experimentally realized.

A slide showing the temperature scale was shown, which revealed the restricted range of temperature to which most scientific inquiries are confined, and it was pointed out that nature grows less complex as we depart in either direction from the temperature

at which organic life exists; that by studying conduction at high temperatures many complexities become eliminated which permits us to better understand electrical conduction at temperatures where we use it; and that the sharp distinction we are accustomed to make between conductors and insulators only belongs properly to the lower half of the highest temperature range obtainable—from 0 deg. to 4000 deg. absolute.

The leading facts of conduction now known were summarized. The work of Onnes, who showed that some pure metals have infinite conductivity at about 4 deg. absolute, were referred to and his curves were shown. At low temperatures the insulators have infinite resistivity while the alloys are intermediate in resistivity.

At elevated temperatures comparatively few facts are known regarding conduction on account of the experimental difficulties heretofore met with in making accurate measurements. These experimental difficulties being in large part now removed, we are able to show the characteristics of the conduction of nonmetallic solids and the conduction of metals in the solid and molten state to temperatures as high as 1500 deg. C.

Slides were shown (six made by Dr. Sommerville and ten by Dr. Northrup) giving curves which accurately express the variation of resistivity with temperature of several oxides of the metals and of the pure metals Na, K, Hg, Cd, Pb, Zn, Sn, Bi, Sb, Cu, Al, Au, and of the alloys Na+K, and brass. It was pointed out that all of these metals and alloys with the exception of bismuth and antimony, suddenly increase in resistance in passing from the solid to the liquid state.

In general the ratio of the resistivity just after fusion to the resistivity just before fusion, is roughly 2.

This ratio for bismuth is 0.478 and for antimony about 0.75. Both of these metals contract on liquifying.

With the exception of zinc, cadmium and antimony, the increase in resistance with temperature of the metals in the molten state is very nearly linear. In the case of gold and copper, which were examined to over 1450 deg. C., the increase in the molten state is exactly linear.

Methods for making these measurements were then considered under the headings—Methods of producing the temperature, of measuring the temperature and of making suitable holders for refractory materials at temperatures where everything conducts and for metals in the molten state. A large and small model of the new "Northrup high-temperature furnace," in which platinum may be melted, were exhibited and their construction explained and uses demonstrated. This has been described in detail in this journal. A slide was shown of the veteran furnace in which many measurements were made to temperatures as high as 1600 deg. C. and under.

Slides were shown of a new device, called a "cascade attachment," which may be quickly placed in the large type furnace and by means of which a temperature may be readily obtained which will melt tungsten, or even vaporize carbon. (See also the article by Dr. Northrup on this subject on page 305 of this issue). Any lower temperature can also, by its means be obtained and held. It was pointed out, that because of the black-body conditions obtained and the fact that the heated zone can be directly looked into without an intervening window of unknown light-absorbing power, radiation at temperatures blending into that of the arc may be conveniently studied.

A summary of the facts of conduction at high temperatures was given and a chart shown which summarized the special characteristics of the metals. The interesting relation was brought out that for six of the metals, for which data have been obtained, the ratio of the coefficient of resistance to the coefficient of cubical expansion of the metal when in the molten state, is approximately constant; that this holds true for potassium and tin; though the former has ten times the expansion of the latter.

Suggestions were then given for investigations on the subject of conduction which are important for the future. The most important of these suggestions being that the cubical expansion coefficients of molten metals should be determined and that the resistivity should be studied of metallic vapors when near their critical temperature and pressure. The speaker expressed his belief that we do not yet know enough facts of electric conduction and related physical properties over a wide range of temperature to make it possible to formulate a satisfactory theory of conduction and that present theories are certainly inadequate to explain the facts of conduction as they have been observed at the low temperatures at which Onnes worked, to the temperature of 1500 deg. C., at which accurate data for some of the metals have been obtained.

Electric Properties of Silver Sulphide

Mr. F. A. J. Fitz Gerald, of The Fitz Gerald Laboratories, Niagara Falls, N. Y., followed with a very interesting paper, entitled "Laboratory Notes on Some Electrical Properties of Silver Sulphide," and illustrated by lantern slides and some pretty experiments. The study of the electrical properties of silver sulphide was undertaken by the author in connection with the commercial development of an automatic fire alarm invented by Mr. E. Garretson.

The conclusions of Mr. Fitz Gerald's paper are as follows:

Silver sulphide is a solid electrolyte well worthy of study, since it lends itself admirably to experiments having for their object research on the properties of electrolytes of this class.

The temperature-resistance curve of silver sulphide shows a critical point at a certain temperature, but this is not the same on the heating and cooling curves.

The temperature-resistance curve of silver sulphide is strongly affected by impurities. Thus pure silver sulphide gives a critical point with rising temperature at 170 deg., sulphide from an alloy containing 0.5 per cent copper has a critical temperature of 163 deg., and that made from the 7.5 per cent allow a critical temperature of 104 deg. In this relation it is interesting to note that Northrup has found a critical temperature for alundum at 1100 deg.

Silver-silver sulphide and copper-silver sulphide form thermoelectric couples, the effect of which must be looked for in experimental work on silver sulphide.

Even very slight chemical reduction in a mass of silver sulphide has a great effect on its electrical resistivity.

Lack of homogeneity in the sulphide made from silver-copper alloy has an important influence on its electrical properties. The resistivity is greatly affected, and probably also other characteristics such as the thermoelectric and rectifying effects. Much of the experimental work on this point has not been mentioned because it is of too incomplete a character, but the observations made are such as to warrant a warning. This would probably explain certain anomalies which may be found in the case of mixed sulphides. These anomalies are comparable to the case of alloys

where there may be a "false resistance" due to thermoelectric effects, as pointed out by J. J. Thomson.

Electrolysis may occur in a $Cu - Ag_2S + Cu_2S - Cu$ cell in a 25-cycle A.C. circuit, with the result that the cell is eventually short-circuited. On the other hand, if silver electrodes are used the cell is not short-circuited.

Electrolysis in the $Cu - Ag_2S + Cu_2S - Cu$ cell is probably due to a persistent rectifying effect. This rectifying effect is very marked in a cell where one copper electrode is coated with cupric oxide.

A rectifying effect may also be shown with an $Ag - Ag_2S + Cu_2S - Ag$ cell, but after being in an A.C. circuit for some time this disappears.

In the $Ag - Ag_2S + Cu_2S - Ag$ cell showing a rectifying effect there is a critical temperature at which this disappears on heating, and a different critical temperature at which it reappears on cooling. These critical temperatures may be correlated with the critical points of the temperature-resistance curves. Study of this phenomenon might throw some light on the nature of conduction in solid compounds, whether this is electrolytic or electronic or both.

Polarization Single Potentials

A paper by **Mr. Claude N. Hitchcock** gives an account of an investigation carried out at the University of Wisconsin with reference to a former experiment of Dr. J. W. Richards, who obtained decomposition of water at an impressed e.m.f. of only 1.15 volts, instead of 1.67 volts, the generally accepted value of the decomposition voltage of water. This result had been obtained by the use of platinum electrodes differing greatly in size. The present author's investigation was undertaken for the purpose of determining the potential at each electrode in such cases of decomposition of electrolytes below the normal decomposition point.

The conclusions reached are as follows:

Decomposition of water can be accomplished at any voltage with platinum electrodes, provided the latter are of the proper size.

The oxygen normally present in laboratory reagents is sufficient to produce marked depolarization at the cathode.

The single potential of each electrode so depends on that of the other that any change in one, due to disturbing influences, is counteracted by such a change in the other that, below the decomposition point, the sum of the separate electrode polarization equals the total polarization, and this in turn equals (very nearly) the impressed electromotive force.

Any desired current may be passed through an aqueous solution of sulphuric or hydrochloric acid without causing evolution of gas, provided the electrodes are made large enough.

The evolution of gas at the electrodes depends on the total current density minus that part of the current density neutralized by the action of depolarizing agents.

Determination of Free Energy

Dr. Reinhard Beutner, of the Rockefeller Institute of Medical Research, New York City, presented a paper on a "new cell arrangement for direct determination of free energy." This paper gives the results of a continuation of the researches which the author has described in former valuable papers before the society.

In his present paper it is shown how galvanic elements can be arranged so as to measure, without transfer potential, the free energy of reactions between solid salts and metals or between solid salts alone. These cells are mostly characterized by containing solid salts in the path of the current.

If two reacting constituents are present in mutual admixture, the reaction can no longer be treated as "fixed," since osmotic forces then come also into play. But even for such cases suitable galvanic cells for measuring the free energy are described. To these belong, for instance, the formation of salt hydrates, in which it is almost always found that the resulting salt hydrate is considerably soluble in water, and in consequence a fluid mixture of salt hydrate and water enters into the reaction.

Further, new electrometric methods were given for chemical reactions of the kind described, in which the reacting constituents were present diluted by indifferent bodies. To such belong especially such reactions in which salts take part in practically completely dissociated dilute solutions. It could be shown in what way cells could be arranged for the measurement of reactions, avoiding the diffusion potentials, as, for instance, the reactions in the Bredig-Knüpffer cell.

Railway Track Cell

The paper by **Mr. E. L. Marshall,** of the National Carbon Company, Cleveland, Ohio, described a new cell of the wet type which has been developed within the last ten years for service in railway signalling Its predecessor in the same field was the Daniell gravity cell.

The paper describes the general electrical equipment for automatic block signalling and shows that a cell for the track circuit must fulfil the following requirements: low current on short circuit, constant voltage on closed circuit, large capacity, small fluctuations due to variations in temperature.

The Lalande type of cell was selected to develop a cell of this kind. It is a single-fluid cell with a zinc anode, a cathode of copper oxide and an electrolyte of caustic soda. There had already been perfected a Lalande cell with a low internal resistance and consequently a high amperage on short-circuit. But for the present purpose a high internal resistance was required.

To get a high internal resistance in a Lalande cell use was first made of a perforated porcelain plate placed between the zinc anode and copper oxide cathode. But a more efficient cell was later developed in form of the Columbia track cell. The high internal resistance is obtained in this cell by merely separating the two electrodes a long distance apart in the electrolyte, no added piece being used for the purpose. The construction of the cell is described in some detail and its advantages are pointed out.

Experiments on White Lead

A paper by **Mr. R. Stuart Owens** gives the results of experiments undertaken to determine in what way and to what extent the character of precipitated white lead is affected by the conditions of precipitation.

Among other experiments the author produced white lead electrolytically on a laboratory scale according to data obtained from the patents of Woltereck and Luckow. The experiments proved that these two electrolytic methods are not run under conditions which give the best precipitate of white lead.

Electrolytic Iron

A paper by **Dr. Oliver W. Storey,** of the University of Wisconsin, gives the results of a "microscopic study of electrolytic iron," prepared by the refining process of C. F. Burgess. The paper is illustrated by 48 microphotographs.

The results of the study of heated electrolytic iron are summed up as follows:

No change in structure of electrolytic iron could be determined at temperatures below the A_3 range.

A fine deposit is more readily changed to the grain structure than a coarse deposit.

With a short heating above the A_3 range the fine deposit is transformed into a fine grain structure, while a coarse deposit becomes coarse grained.

The coarse grains resulting from a coarse deposit may be broken down into smaller grains by long annealing at the Ac_3 point or by heating to 1000 deg. or higher.

The grain structure resulting from a fine structure is always finer than that resulting from a coarse deposit.

The grains of electrolytic iron do not grow appreciably at 1150 deg.

The microstructure of fused electrolytic iron was next studied and is illustrated by microphotographs.

Rolled electrolytic iron shows the structure of clean furite.

The Effect of Addition Agents in the Electrodeposition of Iron

A paper by Messrs. **O. P. Watts** and **N. H. Li** gives the results of experiments on various addition agents in the electrodeposition of iron.

Previous experience in refining iron had shown that, while an electrolyte containing only chlorides gave a much smoother deposit than one consisting of the sulphates of iron and ammonia, the iron produced rusted so badly after removal from the electrolyte that a pure chloride electrolyte was not considered practical.

It was found, however, that the admixture of some chloride with the sulphate electrolyte improved the smoothness of the deposit without causing excessive rusting of the iron produced.

The electrolyte chosen as a basis for the addition of various substances consisted of 150 grams crystallized ferrous sulphate ($FeSO_4.7H_2O$) and 75 grams ferrous chloride ($FeCl_2.4H_2O$) per liter, and had a specific gravity of 1.125 at 20 deg. C.

The objectionable features of electrolytic deposits of iron are a roughness which increases with the thickness of the deposit, and a tendency to form vertical grooves or striations. The color of the electrolyte at the end of the test was closely related to the quality of metal produced. A yellowish-green electrolyte almost invariably gave clean metal of a fine color, even though it might be too badly pitted to allow of the practical use of that particular electrolyte. A dark electrolyte fouled by much green precipitate usually yielded very bad-looking metal.

The experiments show that ammonium oxalate and formin are capable of improving upon the smoothness and satisfactory deposits given by the original electrolyte.

* * *

The following is a complete alphabetical list of those who registered at the meeting; where no address is given, New York City is understood:

Paul O. Abbé, Lawrence Addicks; Chas. H. Aldrich, Perth Amboy, N. J.; R. J. Alexander; H. I. Allen, Wilmington, Del.; C. Arick, East Orange, N. J.; Mr. and Mrs. W. C. Arsen, Schenectady, N. Y.; Dr. and Mrs. L. H. Baekeland, Yonkers, N. Y.; D. K. Bachofner, Irvington, N. J.; T. F. Baily, Alliance, O.; H. A. Baker, R. L. Baldwin, A. Barnett; Wilder D Bancroft, Ithaca, N. Y.; Mr. and Mrs. Chas. Baskerville, E. A. Beck, E. H. Bedell, V. A. Belcher; C. W. Bennett, Ithaca, N. Y.; R. Beutner, D. D. Bergoheimer, Wm. Bjorkstedt; A. Blaicher, Newark, N. J.; W. F. Bleecker, Canonsburg, Pa.; Walker Bowman, Dudley Boyd, Jr., State College, Pa.; M. Brasell, Perth Amboy, N. J.; A. A. Breneman, Mrs. A. E. Brisben, R. D. Bricknell, Mrs. W. E. Brisben; C. O. Brown, Pittsburgh, Pa.; C. B. de Browne, D. H. Browne; J. K. Bryan, Perth Amboy, N. J.; C. L. Bryden, Scranton, Pa.; J. A. Brundige; M. H. Burnett, Waterbury, Conn.; F. A. Butterick; A. S. Callen, Philadelphia; H. G. Cannon, Keokuk, Ia.; Carmichael, Boston, Mass.; H. R. Carveth, Niagara Falls, N. Y.; Dr. Margaret A. Cleaves, C. C. Coates; Jesse Coates, Lynn, Mass.; H. B. Coho; E. A. Colby, Newark, N. J.; Daniel S. Collins; W. W. Colquhom Zanbridge Wells, England; E. F. Cone; H. R. Connell Pittsburgh, Pa.; Mr. and Mrs. Wm. A. Cowan; Mr. and Mrs. A. H. Cowles, Sewaren, N. J.; J. S Crider, Cleveland O.; Ed. L. Crosby, Detroit, Mich.; T. E. Crossman; N. J. Cummings, Haskell, N. J.; H. M. Cushing, Buffalo, N. Y.; N. E. Dabolt, Mt. Vernon, N. Y.; A. W. Davison, Ithaca, N. Y.; L. C. Diefahl, Cleveland, O.; Wm. H. Doering, Philadelphia, Pa.; C. A. Doremus, J. V. N. Dorr, Mrs. G. D. Dorsey; R. G. Dorsey, Dayton, O.; James Douglas; J. Dunwald, Perth Amboy, N. J.; A. S. Dwight; W. Dyrssen, Bethlehem, Pa.; Charlton Ellis, Montclair, N. J.; O. A. EnHolm; G. W. Emanuel, Perth Amboy, N. J.; Marion Eppley, E. F. Eurich; C. D. Ferguson, Wm. Ferguson; Mrs. C. G. Fink, East Orange, N. J.; C. M. FitzGerald; Mr. and Mrs. F. A. J. FitzGerald, Niagara Falls, N. Y.; Mr. and Mrs. C. B. Foley, Dayton, Ohio; L. W. Fogg, State College, Pa.; O. R. Foster, C. M. Foyce, Dr. K. G. Frank; M. W. Franklin, East Orange, N. J.; Hy. E. French, Farmington, Conn.; R. H. Gaines; A. J. Ganz, Hoboken, N. J.; R. E. Gegenheimer, Waltham, Mass.; J. J. Gerety, Philadelphia, Pa.; A. E. Gibbs, Philadelphia, Pa.; H. W. Gillett, Ithaca, N. Y.; Rob. R. Goodrich; Arnold J. Guerber, Canonsburg, Pa.; John Haddow, State College, Pa.; R. L. Hallett; Fred J. Hambly, Buckingham, Quebec; Carl Hamsbuchen, Belleville, Ill.; A. V. Hansell, C. A. Hansen, Schenectady, N. Y.; H. M. Harbach, State College, Pa.; J. L. Harper, Niagara Falls, N. Y.; Leon O. Hart, Hanson, N. J.; Carl Hering, Philadelphia, Pa.; J. B. F. Herreshoff; J. B. Herreshoff, Jr., Richmond Hill, N. Y.; Henry Hess, Philadelphia, Pa.; H. L. Hess, Jr., Philadelphia, Pa.; H. D. Hibbard, Plainfield N. J.; E. F. Hicks, Philadelphia, Pa.; A. J. Hinckley, Niagara Falls, N. Y.; Allan Hirsch; Wm. G. Horsch, Newburyport, Mass.; G. A. Hulett, Princeton, N. J.; R. C. Hull; Ernest Humbert, Niagara Falls, N. Y.; W. Hummell, High Bridge, N. J.; L. D. Huntoon; Mr. and Mrs. O. Hutchins, Niagara Falls, N. Y.; R. M. Hutchinson, State College, Pa.; E. B. Jewett, Clarksburg, W. Va.; H. de Joannis, Bridgeport, Conn.; J. E. Johnson, Jr., W. McA. Johnson; Mr. and Mrs. M. C. Joyce, Arlington, N. J.; Edw. G. Keller, Perth Amboy, N J.; Mr. and Mrs. H. W. Kellogg, Niagara Falls, N. Y.; Philo Kemery, Pittsburgh, Pa.; E. F. Kern, L. J. Krom, Walter Laib, Rittman, Q.; M. J. Langdon; F. C. Langenberg, Cambridge, Mass.; John Langton, Ernst Leitz; F. Austin Lidbury, Niagara Falls, N. Y.; D. M. Liddell; C. F. Limpay, Bridgeport, Conn.; P. M. Lincoln, Pittsburgh, Pa.; E. A. Lof, Schenectady, N. Y.; R. L. Lloyd; S. J. Lloyd, University, Ala.; G. E. Love; A. Lowenstein, Chicago, Ill.; F. W. Lowry, State College, Pa.; G. V. Luerssen, State College, Pa.; G. P. Lunt, Boston, Mass.; D. A. Lyon, Pittsburgh, Pa.; F. W. Manger, Jersey City, N. J.; A. S. McAllister, J. S. McClenehan; K. W. McComas, Perth Amboy, N. J.; James H. McGraw; F. Maeulen, F., Prince Bay, N. Y.; E. L. Marshall, Fremont, O.; W. W. Macon; Wm. D. Mainwaring, Cleveland, O.; Mr. and Mrs. A. B. Marion, Edw. J. K. Mason; J. A. Mathews, Syracuse, N. Y.; H. A. Mayer, Portland, Ore.; W. W. Merrill, Salisbury, Mass.; Albert Meyer, Irvington, N. J.; C. Mindeleff, Perth Amboy, N. J.; Mr. and Mrs. Geo. P. Moore, Hartford, Conn.; J. M. Muir, Paul I. Murrill; R. E. Myers, East Orange, N. J.; A. F. Nagle, N. Nikune, J. R. Noeggerat; Mr. and Mrs. E. F. Northrup, Princeton, N. J.; G. Ornstein; I. Paris, Boston, Mass.; H. C. Parmelee, Denver, Col.; Chas. L. Parsons, Washington, D. C.; J. C. Pennie, Kenneth R. Pennie, F. P. Pennington, O. M. Perry; M. Petinot, Niagara Falls, N. Y.; W. L. Raup, Perth Amboy, N. J.; Thos. T. Read; O. R. Reed, State College, Pa.; Louis Ruhe, O. H. Rucker; A. R. Rhoades, State College, Pa.; Mrs. E. F. Roeber, East Orange, N. J.; C. D. Robb, Essex Fells, N. J.; Mr. and Mrs. C. L. Robbins, Wilkes-Barre, Pa.; E. F. Roeber; G. A. Roush, South Bethlehem, Pa.; Mrs. G. A. Roush, South Bethlehem, Pa.; Joseph W. Richards, Lehigh University; C. B. Sadtler, Denver, Col.; P. G. Salom, Philadelphia, Pa.; E. M. Sargent, Niagara Falls, N. Y.; L. E. Saunders, Niagara Falls; W. M. Saunders, Providence, R. I.; C. G. Schluederberg, Pittsburgh, Pa.; D. F. Schuetz; Philip Sievering, Newark, N. J.; Alex. Smith; John A. Seede, Schenectady, N. Y.; Dyer Smith, E. A. Sappelen Smith; Tracy Smith, Waterbury, Conn.; W. F. Smith, Philadelphia, Pa.; W. O. Snelling, Pittsburgh, Pa.; J. A. Schweiger; M. Snyder, Perth Amboy, N. J.; N. W. Sothman; J. L. K. Snyder, Mamaroneck, N. Y.; Geo. E. Speim, H. N. Spicer, E. G. Spilsbury; F. A. Stamps, Niagara Falls, N. Y.; S. A. Staples; Chas. P. Steinmetz, Schenectady, N. Y.; Dr. E. R. Steinhardt, Miss L. D. Steinhardt, Bradley Stoughton, G. C. Stone, Dr. Jos. Struthers; E. R. Sutcliffe, Leigh Lanes, England; W. T. Taggart, Philadelphia, Pa.; Jokichi Takamine; John B. Taylor, Schenectady, N. Y.; A. C. Terrill, Glendale, Cal.; Mrs. A. C. Terrill, Glendale, Cal; S. A. Tucker; C. C. Turnock, State College, Pa.; E. N. Todd, Newark, N. J.; F. J. Tone, Niagara Falls, N. Y.; R. Turnbull, Welland, Ontario; K. Usui, Tokio, Japan; T. Usui, R. H. Vail; I. R. Valentine, Schenectady, N. Y.; G. D. Van Arsdale; A. Van Winkle, Newark, N. J.; C. H. Von Bauer, Douglaston, N. Y.; W. E. Volz; Mr. and Mrs. Alois Von Isakovics, Monticello, N. Y.; Mr. and Mrs. L. D. Vorce, Wyandotte, Mich.; A. L. Wacken, J. H. Ward, C. M. Wales, C. H. Wang; C. A. Weeks, Philadelphia, Pa; Harry B. Weiser, Ithaca, N. Y.; Mrs. J. R. Wettstein, Mt. Vernon, O.; Thos. F. Wettstein, Perth Amboy, N. J.; W. V. Whitney, Schenectady, N. Y.; Elliott H. Whitlock, Cleveland, O.; M. C. Whitaker; R. H. White, Niagara Falls, N. Y.; R. P. Williams, Waltham, Mass.; A. M. Williamson, Niagara Falls, N. Y.; W. W. Winship, H. C. Wirt, Roy U. Wood; W. J. Wooldridge, Pittsfield, Mass.; W. J. Yabrevitch, Pittsfield, Mass.; M. A. Yurick, South Orange, N. J.

Iron has been produced experimentally in the electric furnace at the foundry of the Carnegie Institute of Technology, Pittsburgh. The experiments were in charge of Mr. **Frederick Crabtree,** professor of metallurgy at the Institute. Raw Mesabe iron ore was converted into high-grade pig iron.

The Senate radium hearing before the mines and mining committee was attended by practically the same interested parties as appeared before the House committee. No new features were developed. The arguments pro and con were about the same as brought out before. Both hearings have been published and can be secured by those interested.

Some Economic and Aesthetic Aspects of Electrochemistry*

BY E. F. ROEBER

There is beauty in electrochemistry. The late Ludwig Boltzmann once said that of all artists the mathematical physicist is nearest to the world's Creator in the simplicity, directness and economy of his methods; Boltzmann made this remark in appreciation of the work of Kirchhoff and Maxwell. But we can apply it with equal truth to the electronic theory of our own time which in the simplicity of its fundamental conceptions and in the comprehensiveness of its outlook has all the elements of pure beauty. The intellect which builds the structure of the atoms of the different chemical elements out of a positive electric nucleus in association with varying numbers of negative electrons, and makes his atoms produce the desired result, is a true creator, and his model has beauty like the visible world around us.

But more beauty is hidden in electrochemistry than the mathematical beauty of electrochemical theory. The research electrochemist who works out a new process whether it is the reduction of aluminium from its oxide, or the conversion of amorphous carbon into graphite, or the production of calcium carbide from lime and coke, or whatever else, proceeds exactly along the same methodical lines as the artist, whether he be sculptor or painter or poet. The artist must take nature as it is. But for his work he takes from nature only what his imagination tells him to be essential to the idea he has in mind. It is this selective copying of the essential from nature and this restriction to nothing but the essential that makes a work of art beautiful.

The method is exactly the same with the creative electrochemist. He cannot improve on Nature's processes and methods. All he can do is to imitate or copy Nature's processes and combine them to a certain end. But because his goal is a certain product he can select the starting materials which are essential and use nothing else, and he can select those processes which are essential and combine them into the most direct method of production, and produce only what is wanted. Artificial graphite made in the electric furnace is superior to natural graphite, because nature does not set out to make pure graphite and man can. This makes the economic value of artificial graphite; but it also makes the artificial graphite process, in the bold directness of its execution, a true work of art. Wherever a process is so designed as to reach its object in the most direct way with greatest economy, it is beautiful in the eyes of those who understand its rationale. This is broadly true and not restricted to electrochemistry; but the trained engineer's or scientist's intellectual eye is needed to see this type of beauty.

The thoughts on some particular aspects of electrochemistry which I want to submit to you for reflection tonight are of a cognate nature. They refer to the part which electrochemistry plays in the changes now going on in modern civilization in economic and æsthetic valuations. Our age is called an age of unrest and revolution. Whether we are really so much more restless than our ancestors is open to discussion and hard to decide. But that the scientific and concomitant engineering advances of the last century have brought an entirely new phase (in the phase-rule sense) into the play of human reactions which make up the history of mankind, is not open to question. That the effects of modern science and engineering go far beyond their spheres of immediate interest is undisputed. What then is the effect of electrochemistry on two fields apparently so remote as political economy and æsthetics?

To express the question concisely I borrow Friedrich Nietzsche's phrase of the revaluation of values. My subject is: How does electrochemistry bring about a revaluation of economic and æsthetic values? I have brought Nietzsche's name into this discussion for still another reason. Nietzsche's brilliant and, at first sight, extraordinarily daring attempt of a revaluation of ethical values for the sake of creating the "Uebermensch," is perhaps in the final analysis of its positive aspects nothing more than a robust reassertion of what was strong and healthy in the viewpoints and valuations of classic Greece and Rome, but has been lost in the last nineteen centuries to an exaggerated weak sentimentality. Nietzsche wanted to make restitution of this lost strength and health from classic Greece to modern civilization and thus create a new ethics. Now, it would seem that the effect of science and engineering on æsthetics is acting at present in the same direction in emphasizing the necessity of a return to the æsthetic viewpoint of classic Greece, as embodied in Socrates' view of the kinship of beauty and utility. It is for this reason that before speaking of æsthetic aspects of electrochemistry it is necessary to take up its economic aspects.

How are economic values being created by industrial electrochemistry? For this discussion Professor Karl Knies' old and well-known conception is very useful: that economic value is of three kinds—place value, time value and form value. If I may use the text-book illustration, ice in winter in the Maine woods has no economic value because there is no market for it there. Brought to New York, it gets place value, because there is a demand for it in New York. Stored and sold in summer time, it gets an additional economic value—time value. Nothing has been done to the ice itself by man. The place value has been created by transportation, the time value by storing, and as we will see later these two points are of importance for the production of economic values by electrochemistry.

But for the present let us consider the third kind of economic value—form value—that is the value created by the work done by man on the materials of nature, comprising mechanical work as well as chemical changes. Any chemical reaction produces or annihilates form values, economically speaking. But what is the distinguishing characteristic feature of the form values produced by the electrochemical industries? Let us take a few typical examples.

By the electrolysis of a solution of common salt we get caustic soda and chlorine, and we work up the latter perhaps into bleaching powder. The excess of the value of the caustic soda and bleaching powder over that of common salt is the form value produced by this process. So it is in the production of calcium carbide from lime and coke, of nitric acid and nitrates from atmospheric air and so on.

The fixation of atmospheric nitrogen, representing an extreme case, is most instructive. The raw material is atmospheric air which, as such, has no economic value at all, so that we might say that in the production of nitrate from air the economic efficiency becomes infinitely high. It sounds very well to speak of a process with an infinitely high economic efficiency, but if we stop to remember that exactly this process which is now worked with fair financial results in Norway proved a commercial failure some ten years ago in Niagara Falls, it is evident that our consideration must have been in some way so one-sided as to be misleading.

Why was fixation of atmospheric nitrogen a failure at Niagara Falls and why is it a success in Norway? Not primarily on account of the process, because the Brad-

*Presidential address delivered before the American Electrochemical Society on April 16, 1914.

ley-Lovejoy process worked with about the same technical efficiency as the Birkeland-Eyde process, though the apparatus was considerably more ecomplicated. No, the decisive element which caused failure at Niagara Falls and success in Norway, is the cost of electric power which is three to five times lower in Norway than at Niagara Falls. And this brings us right to the root of the whole matter.

In discussing the economic value of some electrochemical products we have so far, in a one-sided way, compared only the value of the starting materials and of the end products; but we have entirely neglected the fact that in these cases we have to do not only with materials as such, but rather with the storage of energy in materials. The form value of many products of electrochemical industries is essentially due to their high energy content. A large amount of chemical energy is stored in electrochemical products; it is latent under ordinary conditions, but it may be gotten out wherever and whenever necessity arises, and this fact makes them useful and economically valuable.

Let us carry this consideration a little further by making use of the conception that the energy of a given system may be considered as the product of two factors —the capacity factor and the intensity factor, to use the terms of Ostwald. The total amount of energy remains the same, however the two factors may be changed, if only their product remains the same. But for the engineering applications it makes an enormous difference whether we make the capacity factor small and the intensity factor large or the former large and the latter small.

In case of a waterfall the amount of water passing over the fall in a certain time is the capacity factor, the height of the fall is the intensity factor. The engineering requirements for the development of a waterfall with little water and a high fall are very different from the case of a lot of water with a small fall, though the energy may be exactly the same in both cases.

In the case of electrical energy the current passing in a certain time, measured in coulombs, is the capacity factor, the pressure in volts is the intensity factor. For electric power transmission we make the intensity factor, the voltage, as large as possible, in order to decrease the transmission loss.

In the case of electrochemical products, the weight of the materials is the capacity foctor, the specific energy stored in them per unit of weight is the intensity factor. If we make the latter high, if we store a lot of energy in a little matter, it will again be favorable in reducing the cost of transportation.

Now the element of transportation brings us to the conception of the place value of electrochemical products. If their form value is due to their high energy content, their place value is due to the possibility of chemical power transmission by material transportation of electrochemical products. Those products of the electrochemical industries which are characterized by a high specific energy content are the principal medium of chemical power transmission.

There are two points of chemical power transmission to be specially emphasized. One is that it is not bound to a fixed route. It requires no line wires. It makes use of the ordinary transportation facilities for materials—railways, ships, etc. This is important, as it opens fields for chemical power transmission where electrical power transmission fails. For instance, there are still very large areas in this country, Canada and elsewhere which are so little populated that it would not pay to erect an electric transmission system to provide electric current for lighting. Here acetylene lighting is of supreme importance. And acetylene lighting is a case of chemical power transmission. At Niagara Falls the electric furnace produces calcium carbide from lime and carbon, and chemical energy is thus stored in the carbide which is transported with its energy to any place where acetylene is required for lighting.

If transportation creates place value, storage creates time value. The use of chemical energy after it has been transmitted is not bound to a certain time and that is the second important feature of chemical power transmission. With electrical energy which cannot be stored as such, it is necessary to use the transmitted energy at once or to provide special means for storing it. In this respect chemical power transmission differs essentially from electric power transmission and is superior to it. Chemical energy is in itself essentially stored latent energy, and is used, therefore, in connection with other systems of power transmission for storage purposes, as in the case of storage batteries for electric power systems. The time value of calcium carbide is due to the fact that we can store it and can produce the acetylene just at the moment when it is needed for lighting.

There is a long list of electrochemical products which may be considered from the viewpoint of chemical power transmission. In bleaching powder we transmit the possibility of producing a bleaching or a disinfecting liquid whenever and wherever it is needed. In the series of peroxides we transmit their avidity to give off an atom of oxygen when and where we want it, or the reaction caused by it.

As pretty and concrete an illustration of chemical power transmission as we may wish is found in Hans Goldschmidt's ingenious aluminothermic reaction. The heat of reaction of aluminium and oxygen in forming alumina is relatively very high per unit of weight of aluminium. This is just the reason why the economical reduction of aluminium from alumina did not succeed until electrolysis was resorted to. Now, the fundamental idea of the aluminothermic method is that we have in metallic aluminium a medium which gives us by combination with oxygen a large amount of energy whereever or whenever needed. In thermit, the mixturue of aluminium and iron oxide, we transport essentially the capability of producing at any place and at any time highly superheated molten steel for welding rails, for making repairs, and so on.

Again, in the new and important Norwegian nitrate industry we have an example of what we may call international chemical power transmission, as the economical value of Norsk saltpeter depends on its easy transportation by ship to other countries. Thus we have at the same time creation of economic values in Norway by building up a new and important industry, and creation of economic values in other countries by using the Norsk saltpeter to further agriculture.

I have dwelt on the relation of electrochemistry to chemical power transmission at such length because so many electrochemical products can be considered from this viewpoint. But it would be wrong to think that the whole of electrochemistry can thus be viewed. There is quite a number of very important electrochemical products in which with no stretch of imagination I am able to detect the elements of chemical power transmission. But in all such cases the form value is high.

In the case of aluminium we have the aspect of chemical power transmission only in the aluminothermic reaction, which though big in itself, uses only a small amount of the total output of aluminium. In cooking utensils, in line-wire construction and other applications it is simply the mechanical and electrical properties of aluminium which count and which give it a high form value.

In electrolytic copper refining, the oldest and certainly one of the biggest electrochemical industries, the in-

crease of form value is remarkable. It is a double one. First, the gold and silver are recovered; second, the copper itself is considerably increased in form value, due to its greater purity and resulting higher electric conductivity.

All those products of electrochemical industries which have nothing to do with chemical power transmission have a high form value, and must have it, because otherwise it would not pay to use an electrochemical process in view of the high cost of electrical power. Hence, the well-known axiom that in all such applications the use of electrochemical processes should be restricted as much as possible to the finishing touches, that is, to the refining of a comparatively advanced product.

In addressing the American Electrochemical Society I need hardly show at length how this creation of economic values by the electrochemical industries has affected and is affecting modern civilization in its various phases. What was waste before and what was considered a nuisance, becomes valuable. When the early Colorado gold seekers discovered tungsten ore in Boulder county they cursed it as it was not what they wanted. From their cursed "heavy black sand" electrochemistry has given to civilization ferro-tungsten and the tungsten lamp. From culm, the waste material of the anthracite coal mines Acheson has given to the world artificial graphite with its immense applications. Then there are the grand electric-furnace industries of artificial abrasives in use in so many walks of life. And so I could go on through the list of electrochemical products down to Cottrell's electrostatic process of recovering values from obnoxious smelter fumes. Only this, however, I should add, that electrolytic copper refining, itself made possible by the dynamo, has paid back its debt to electrical engineering, and by furnishing high-conductivity copper has made modern electric power transmission possible. And as we have seen, in chemical power transmission electrochemistry has brought into modern civilization an absolutely new element by which what is now waste power is being scattered all over the world to build up industries, to further agriculture with fertilizers, to light cities with acetylene, to aid public health with bleaching powder, and to affect civilization in general in its most heterogeneous aspects. That electrochemists as true creators are bringing about a revaluation of economic values there can be no doubt. But what has electrochemistry to do with æsthetics?

If beauty is perceived through our senses, the first question is: How has modern engineering affected our senses? And the answer is simply that modern engineering has given us artificial senses in addition to our natural senses. In the old days when the few pieces of apparatus in physical and chemical laboratories were home-made affairs, it was said that experimental physicists and chemists should be able to see with their ears and hear by touch, smell with their tongues and measure temperatures with their eyes. Now modern engineering has given us instruments and apparatus which really represent new senses and which are available to a much more general public. And what is more, our artificial senses can be repaired or replaced by new and better ones and they give us permanent records.

I am not stretching the meaning of the term senses in speaking of instruments as artificial senses. To the electrical engineer the readings of the voltmeter and wattmeter are as real and as true indications of the outside world as though he put his head out of the window to feel whence the wind blows. Pyrometers give as real, though much more exact indications of temperature, as the touch by hand of a hot body or the trained eye of the furnace man. The photographic camera is a new artificial eye that preserves the record of what it sees. Successive photographs put together in a moving-picture enable us to crowd into a period of five minutes what may have happened in a year. We can see crystals grow and plants grow. The electric oscillograph gives us a record that permits us to see at leisure transient phenomena that happen in portions of a second and study over them for hours. The telephone stretches the ability of the human ear so that it can hear in Denver what is said in New York. And if we hear our children of three or four years talk to us over the long-distance telephone in such a self-evident, matter-of-fact way as though they were sitting on our knees, we cannot escape the conclusion that a new generation is rising to which the perception of the outside world comes through new senses, and which consequently looks at the world with new eyes. What has electrochemistry to offer to this new generation in æsthetic ideals?

It seems to me that the fundamental contribution which electrochemistry has to make to æsthetics is to carry to its last consequence the principle that waste can never be beautiful. Of course, this principle is as old as art. Waste of words in a work of literature, waste of lines or colors in pictures, waste of space in architecture, have always been considered the opposite of beautiful. But the growing multiplicity of our sensual knowledge, due to the magnified and projected extension of our senses, forces us to see waste where our ancestors saw beauty and had a right to see beauty.

Permit me to concentrate my remarks on the one subject that is uppermost in this connection in the minds of American electrochemists—the question of the power development of Niagara Falls. I use it as a clear-cut example of what is meant by revaluation of æsthetic values by electrochemistry. The magnificent group of electrochemical industries of Niagara Falls, which are the pride of every American electrochemist and should be the pride of the whole American nation, suffers seriously from the power famine due to the cessation of power development by international agreement between the United States and Canada. This agreement is based on the alleged will of the people of both countries to have the falls preserved as a scenic spectacle on the principle of conservation of natural beauty. The battle cry is conservation of natural beauty for the people.

The counter-argument has been made that the natural-beauty conservationists want to conserve something that no longer exists. With this I agree, but I hesitate to agree with the expression usually given to this argument, namely, that if Niagara Falls could be preserved in its original magnificence, it would be worth while, but that Niagara as a majestic spectacle has never belonged to the present generation, that its beauty had been given up to noisy and offensive exploitation long before the first power station was erected.

This may be true, but it seems to me that this argument does not reach the root of the matter. The beauty of Niagara Falls, like all beauty, is subjective in the onlooker. The question is simply: What do we see when we stand at the brink of Niagara Falls?

Our ancestors who knew nothing of the principle of conservation of energy, of transformation of different forms of energy into each other, looked simply at the material side of the Falls and saw beauty and had a right to see beauty. And if we force ourselves into such a one-sided attitude of mind we can still see beauty.

But if we stand as modern men at the Falls with a free attitude of mind, we don't see simply water, we see power. We see the possibilities of using this power for electric power transmission for lighting, traction and industrial purposes on a wider area. We see the even greater possibility of storing this power in electrochemical products and utilizing them all over the land in all walks of life. If we look at the Falls with this attitude of mind which is the natural one for us, every

cubic foot of water that goes thundering over the falls unutilized appeals to us as waste and nothing but waste.

Now waste can never be beautiful. If the artist's selection of the essential and nothing but the essential makes a work of art beautiful, anything that strikes our imagination as waste must prevent æsthetic enjoyment. If we could look at Niagara Falls with the eyes of our ancestors it would be different; but in full possession of our extended senses which an engineering age has given us, the Falls of Niagara—as much of them as is not utilized—must simply impress us as a waste of immense proportions.

And the very element of bigness which was an element of beauty to our ancestors, has necessarily become to us the reverse, emphasizing only more emphatically the criminal negligence of letting waste on such a tremendous scale go on. Undeveloped Niagara Falls remains spectacular even to the modern man, but it is no longer beautiful.

The perverse mind of Nero could enjoy the spectacle of Rome burning. Children and fools might naively delight in a conflagration that would consume for spectacular purposes a million tons of coal a week. We let the equivalent waste go on in waterpower and hear it called saving beauty for the people.

But there is little use in arguing in æsthetic matters. All we can really do is to make people see for themselves, use their own senses, all of them, their natural ones and their artificial ones. This is what engineering development tends to do every day; and we can rest assured that, as certainly as day follows night, a new generation is rising that will use its senses, all of them, and make its own æsthetics and enforce it.

And when that time has come and people look at the Falls of Niagara running dry their imagination will reveal to them immense beauty, health, wealth scattered by electrical and chemical means all over the country, while the grandeur of the whirlpool rapids, unchanged and undiminished will have a higher æsthetic value, a deeper meaning of beauty than it can possibly have for us. The world will then smile at the æsthetic scruples of so many well-meaning people of our own time and will wonder what all that talk of saving Nature's beauty was about.

The Diesel Engine is the title of an artistic, 112-page pamphlet, issued by the Busch-Sulzer Bros.—Diesel Engine Company, St. Louis, Mo. The catalog contains notes on the efficiency, economy, life, construction, operation and fuel of the Diesel engine, and gives illustrations of Diesel plants in 21 states.

Silent Chain Drives.—For the first time an engineering data book has been published by a manufacturing concern which will enable users of power to select the correct silent-chain drives for their work and determine exact costs from list prices shown in the book. Besides giving complete engineering information on silent-chain driving in simple and compact form, Data Book No. 125 describes many uses of silent chain for the efficient transmission of power and gives specific reasons and illustrations showing application in a large variety of uses. Link-belt silent chain is a series of links connected by joints which consist of segmental case-hardened bushings and case-hardened steel pins. The chain is as flexible as a leather belt—as positive as a gear. Its rated efficiency is 98.2 per cent on actual test. It will transmit any amount of power quietly. Over 200,000 installations were drawn upon for the information contained in this data book. The book is the only work of its kind. Copies can be obtained free of charge from the Link-Belt Company, Thirty-ninth Street and Stewart Avenue, Chicago, Ill.

Celebration of School of Mines, Columbia University

Dr. Leo H. Baekeland will be the first lecturer in the Chandler Foundation on the afternoon of May 29 at Columbia University, during the celebration of the fiftieth anniversary of the founding of the School of Mines.

The celebration of the School of Mines begins on the evening of May 28 with a reception in the gymnasium, followed by a dance. On the morning of May 29 there will be a meeting in the gymnasium, at which eminent engineers will speak and honorary degrees will be given to graduates. An alumni luncheon will follow, and the Chandler lecture will be given in the afternoon, the celebration closing with the banquet at the Waldorf-Astoria in the evening.

Personal

Mr. **Paul O. Abbe** has moved his New York office from Room 1203, Johnston Bldg., to Rooms 916-20, of the same building, where he will have larger quarters. Mr. Abbe has recently been made president of the Efficiency Engineering Company, 30 Broad Street, New York City.

Mr. **H. W. Hardinge,** president of the Hardinge Conical Mill Company, has returned to New York City from a two months' trip through the Western mining districts.

Professor E. Heyn, of Berlin, Germany, will deliver the annual May lecture before the Institute of Metals, London. Professor Heyn's subject will be "Internal Strains in Cold-Wrought Metals and Some Troubles Caused Thereby."

Mr. **Henry E. Jacoby** has recently concluded arrangements to act as the Eastern representative of the Vulcan Copper Works Company, of Cincinnati, Ohio, manufacturers of copper apparatus for industrial chemical purposes. Mr. Jacoby's offices are at 95 Liberty Street, New York City.

Mr. **Robert M. Keeney,** has resigned his position as electrometallurgist in the Bureau of Mines, to take effect April 30. He will go to Cornucopia, Ore., where he will have charge of the construction of a 100-ton cyanide plant, tramway and power house for the Baker Mines Co.

Mr. **Albert S. Knight,** of the International Acheson Graphite Co., is now in Europe on a business trip. During the next few months mail addressed to him in care of E. G. Acheson, Ltd., 5 Chancery Lane, London, will be promptly forwarded.

Mr. William D. Mainwaring, who for the past eleven years was connected with the Detroit plant of the Railway Steel Spring Co., as chemist and metallurgical engineer, has opened a consulting business at 866-868-870 Rockefeller Bldg., Cleveland, Ohio, as a production engineer. Mr. Mainwaring was formerly connected with the open-hearth department of the Pencoyd plant of the American Bridge Company, during the installation of the continuous process of the manufacture of steel. All the furnace records of his father, Isaac Mainwaring, who worked out the practical details as to furnaces and process at Chattanooga, Pencoyd and later in England, have recently come into his possession. He now has a continuous record of the progress of steel manufacture from 1891 to the present date.

Mr. **Wm. Acheson Smith,** general manager of the International Acheson Graphite Company, returned from a flying trip to Europe in time to attend the meeting of the American Electrochemical Society on the last day.

Synopsis of Chemical and Metallurgical Literature

Gold and Silver

Nipissing Metallurgical Practice.—The principal new features of the cyanide practice in the low-grade mill of the Nipissing Mining Co., Ltd., Cobalt, Canada, are a wet desulphurizing process to break up refractory silver minerals, and the substitution of aluminium dust for zinc as a precipitant. These and other details of Nipissing practice are given in a paper by **Mr. James Johnston,** published in the January "Bulletin" of the American Institute of Mining Engineers.

On the completion of the company's mill for high-grade ore, where a combination of amalgamation and cyaniding effects a total recovery of 99 per cent from 2500-oz. silver ore, investigations were begun on the best method of treating the low-grade material. Concentration and cyaniding were considered, the former producing a smelting product and the latter silver bullion 999 fine. The estimates of the two plans were as follows:

Comparison of Mills Treating 200 Tons per Day

Commercial assay of ore	30.99 oz.	
Correction on pulp	1.10 "	
Corrected assay	32.09 oz.	
Cyanide mill to yield 90% extraction. Approximate cost, $250,000.		
90% x 32.09 oz. = 28.88 oz. at 52c., plus 3/10c. increase price in marketing		$15.16
Working cost	$3.00	
Express on bullion, $3.50 per cwt. = 23c. per oz. on 28.88 oz.	0.07	3.07
Profit per ton		$12.09
Concentration mill to yield 80% extraction. Approximate cost, $160,000		
80% x 32.09 oz. = 25.67 oz. at 52c		$13.35
Working cost	$1.25	
Marketing concentrates, 10%	1.33	
Difference between corrected and commercial assay on concentrates, 2%	0.27	2.85
Profit per ton		$10.50
Profit per ton, in favor of cyanide mill		$1.59

The actual results obtained in the cyanide mill finally constructed are as follows:

Cost of construction	$254,839
Extraction on a 26-oz. ore, per cent.	92 to 93
Working cost, per ton, less than	$3.00
Tonnage daily treated	244

The following are representative costs for the concrete construction of battery foundation and walls for the building and ore bins.

Battery block	846 cu. yd. concrete	
Building and walls	349 " " "	
Total	1195 " "	using 945 bbl. cement
Labor		$2,669.48
Supplies		3,735.33
Lumber		246.57
Carpenter shop labor		790.86
Machine shop labor		87.78
Teaming		139.34
Fuel		12.85
Air for operating machinery		400.00
Total		$8,082.21 = $6.76 per cu. yd.

Retaining walls and sundry small walls and foundations on the tank-floor level comprised 434 cu. yd., using 485 bbl. cement, and cost $13.09 per cubic yard.

The original estimated cost for the cyanide mill was $250,000. Following is the actual cost of construction, exclusive of the tram lines, washing plant, etc., which would have been common to either a cyanide or concentrating mill.

Cost of Construction of Low-Grade Mill. To January 31, 1913

Store and office buildings	$725.65
Proportion office and supervision	6,652.97
Excavations	29,728.30
Foundations	20,159.39
Buildings over mill	24,618.99
Battery equipment	24,241.42
Proportion electrical equipment for above.	5,267.38
Tube mills and classifiers	23,223.80
Proportion electrical equipment for above.	12,091.02
Slime treatment and storage	31,519.84
Proportion electrical equipment for above.	4,477.26
Cyanide filter plant	14,154.92
Proportion electrical equipment for above.	3,040.71
Piping, pumps, etc	12,886.19
Precipitation	9,989.23
Proportion electrical equipment for above.	239.42
Heating plant	12,333.70
Water Service	5,288.57
Proportion electrical equipment for above.	1,028.13
	$241,666.89
Additional cost for intermediate filtering and desulphurizing equipment not originally included	13,172.63
Total cost of mill	$254,839.52

Briefly the mill practice is as follows: The ore is crushed to 3-in. in gyratory crushers and sent to the washing plant, where it is hand-picked and jigged. The high-grade material thus recovered is sent to the high-grade mill. The low-grade discard from the washing plant is crushed in stamp battery and tube mills in a caustic soda solution, producing a slime which is desulphurized in tube mill and vats containing aluminium. The slime is dewatered and transferred to vats for cyanide treatment, filtered and discharged to the dump. The cyanide solution is precipitated by aluminum dust, and the precipitate is melted and refined to silver bullion 999 fine.

The importance of extremely fine grinding was demonstrated in early experiments. It was considered that all the ore, silver included, should be ground to pass a 200-mesh screen, and then this product classified to take out the minus 200-mesh sand for regrinding, so that only about 15 to 20 per cent of sand, much finer than minus 200-mesh, would remain in the product delivered to the cyanide plant. As an example of the necessity of fine grinding, it is shown that when the pulp delivered to the cyanide plant contained 3 to 4 per cent plus 200-mesh and 30 to 35 per cent sand in minus 200-mesh, the residue after cyaniding will contain from 3.5 to 5 oz. silver per ton. When a grading test shows 0.5 to 1 per cent plus 200-mesh and from 15 to 20 per cent sand in the minus 200-mesh, the residue after cyaniding will contain less than 2 oz. silver per ton.

The wet desulphurizing process used to decompose the silver minerals was initiated by Mr. J. J. Denny. It rests on the fact that the refractory silver minerals are broken up when the slime pulp is brought in contact with aluminium in a caustic soda solution, leaving the silver in a spongy, metallic state readily amenable to cyaniding. This process is carried out by passing the slime through a revolving tube mill in which is a charge of 4000 lb. aluminium in cubes about 1½ or 2 in. After this agitation a further treatment is given in vats lined with aluminium

plates, where the pulp is slowly agitated. This treatment reduces the time of treatment from 120 to 48 hours, and yields a better extraction by 1 to 4 oz. silver per ton. The slime thus treated is filtered before transfer to cyanide vats, where it is treated for 48 to 60 hours by air and mechanical agitation. This treated slime is filtered in a Butters plant, and the solution is precipitated with aluminium dust.

The practical benefits gained by aluminium precipitation are: No fouling of mill solution; more active solution; a regeneration of 0.608 lb. cyanide per ton of solution treated, equivalent to 1.67 lb. cyanide per ton of ore, or 408 lb. per day; recovery of silver precipitate averaging 27,000 oz. per ton, or about 93 per cent silver. The operating cost per ton of ore treated for July, August and September, 1913, calculated on the basis of 7320 tons per month, was $2.952.

The Dome Mill, Porcupine, Ontario, Canada.—Among the interesting papers presented at the annual meeting of the Canadian Mining Institute in 1913 was one on the cyanidation of gold ore at the Dome mine, by Mr. **D. L. H. Forbes.** Dome ore consists of quartz and schisted slate, heavily mineralized with pyrite. When ground it yields a small proportion of colloids, so that the pulp is ideal for settling and filtration under pressure. The gold generally occurs finely divided.

After crushing in gyratory and jaw crushers, the ore is fed to 1200-lb. stamps dropping 6½ in. at the rate of 102 drops per min. Ten-mesh rolled slotted wire screen is used, but tests have been made on other screens to determine the effect on stamp duty, as shown below.

Effect of Screen Opening on Stamp Duty and Product

Mesh	Tons per stamp per day	Screen tests on battery discharge: +60 mesh per cent	+100 mesh per cent	+200 mesh per cent	−200 mesh per cent
16	6.8	41.6	8.8	10.4	38.8
14	7.9	62.0	6.4	6.8	24.8
12	9.0	64.0	7.0	6.0	22.8
10	9.6	59.0	15.0	7.0	19.0

When the mill was started there were primary amalgamating plates in front of the stamps, but with the coarse crushing finally adopted these were abandoned on account of the scouring action of the coarse sand. The relation of the screen used to recovery by amalgamation was as follows:

Mesh of Screens used	Percentage recovery by amalgamation
16	78
14	75
12	55
10	46 to 50

Following the stamps, the pulp is classified into sand and slime, the former being ground in tube mills and returned to the classifiers. The slime is passed over amalgamating plates, which recover from 46 to 50 per cent of the total gold, and thence through classifying cones to recover any coarse gold, amalgam, etc., which is returned to the tube mills. The most economical results are obtained when the slime is ground so that 75 per cent will pass a 200-mesh screen.

The slime leaving the classifiers contains 10 tons of water to 1 of solids. It is thickened in Dorr thickeners to a consistency of 44 per cent moisture. Cyanide is added to the thickened pulp in sufficient quantity to give a solution strength of 1 lb. per ton. The pulp is then agitated in a continuous Pachuca tank system, by means of compressed air at 20 lb. per sq. in. at the receiver. From the final treatment tank the pulp is run to a storage tank, where it is agitated and drawn off intermittently for filtration in Merrill presses. About 20 tons of slime at a dilution of 1.1 is drawn at each charge, filtered, washed with precipitated solution and discharged. A perceptible extraction of undissolved gold takes place during washing. The discharged pulp is again thickened for recovery of water.

The Merrill system of zinc-dust precipitation is used. The value of solution varies from $2.50 to $6 per ton. The precipitate has a value of about $40 per lb. The solution flowing from the press contains from a trace to 8 cents per ton in gold.

The method of preparing the zinc-dust emulsion is to grind the dust with solution in a small tube mill, and feed the discharge in definite amount at a uniform rate to the pregnant solution at the suction side of the pumps. The average consumption of zinc per ton of ore treated is about 0.37 lb.

Gold from retorted amalgam is melted into bars of 990 to 995 total fineness, of which about 100 is silver. The precipitate from the cyanide department is treated with acid, dried, fluxed, briquetted and smelted in a lead furnace. The resulting bullion is cupelled. The slag assays from $40 to $100 per ton, and is retreated later with cupel crusts, etc., whereupon the slag contains only about $3 per ton gold. Cupellation is carried to a point where the metal carries about 0.025 of lead. This metal easily breaks when cool, and is then charged into the tilting furnace, melted and cast into bars. The fineness of this bullion is 990.

Mill operations are controlled by assays of samples taken (1) at the battery pin, (2) at the discharge from batteries, (3) slime leaving amalgamation plates, (4) filter press residues, (5) sluicing water sent to waste with residues, (6) pregnant and barren solutions. Calculated heads, from gold recovered plus gold lost divided by tonnage, agree well with the average of battery samples, but do not check well with battery bin samples. Tonnage is calculated from samples of slime flowing from the tube mill circuit to the thickening tanks. As this pulp contains 10 parts water to 1 part of ore, errors are divided by 10 when referred to dry pulp.

The metallurgical extraction on half-ounce ore is over 95 per cent, divided approximately half and half between amalgamation and cyanidation.

Cyanidation of Silver Sulphide Ore.—The ore in the Ocampo district, Mexico, is practically all argentite, Ag_2S, with some associated gold. The ratio of silver to gold in the ore is about 60.1. The silver mineral occurs usually finely divided, but can sometimes be seen with the naked eye. Something of the history of the metallurgy of this ore, and the projected modern mill for its present treatment is told by **Mr. Robert Linton** in the February Bulletin of the A. I. M. E.

Six mills formerly were operated on the mines now owned by the Sierra Consolidated Mines Co., in the Ocampo district. Until about seven years ago the treatment consisted in plate amalgamation, followed by concentration with pan-amalgamation of the concentrates. Records show recoveries of from 62 to 79 per cent of the gold and from 46 to 64 per cent of the silver. The milling costs ranged from $3.25 to $5.01 per ton.

The first cyanide mill in Ocampo was installed in 1906. It comprised rock breakers, stamps, Wilfley tables, leaching vats for sand, Pachuca agitators for slime, clarifying filter press, zinc boxes and accessory equipment. Concentrates were ground in strong cyanide solution. Sand treatment required from 20 to 25 days, and slime treatment 8 to 10 days. The recovery was about 70 per cent for both metals, and cyanide consumption was more than 5 lb. per ton of ore. Milling cost averaged about $5 per ton.

Tests made under the present management indicated that sand leaching could be eliminated entirely, for better extraction could be made from slime. Where 80 per cent of the silver could be extracted from slime

in 20 hours' agitation with strong solution, the extraction from sand at the end of 18 days rarely reached 75 per cent. Fine grinding is required to expose the silver to the dissolving action of cyanide; the more nearly a fineness of 200-mesh is approached the better is the extraction. The most favorable strength of cyanide solution is 0.32 per cent KCN, and at this strength extractions of 84 to 89 per cent of the silver and 93 to 95 per cent of the gold can be obtained in agitations of 34 hr. duration. Chemical consumption of cyanide is 1.4 lb. and of lime 12 lb. per ton of ore treated. Mechanical losses probably will bring these figures up to 2.5 lb. and 15 to 20 lb., respectively. Protective alkalinity should be maintained during agitation at 0.08. Lead acetate was found to be of no value in the treatment.

Tests on cyaniding concentrates showed the best results by grinding in 0.2 per cent KCN solution and agitating in 0.6 per cent solution, which was raised to 0.8 per cent toward the end of the treatment. Protective alkalinity maintained at 0.10. Lead acetate did not benefit extraction, but a small amount aided in keeping solutions clear. Concentration is not indicated in treating ordinary grades of this ore, though it might be valuable in handling rich ore.

A new mill, which had been designed on these tests, was under construction when work ceased on account of unsettled conditions in Mexico. The equipment will comprise rock breakers, 1500-lb. stamps, tube mills, Esperanza-type classifier, Dorr thickeners, Pachuca agitators, Oliver continuous filter, zinc boxes and accessory equipment.

The coarse breakers will reduce the ore to 2-in. size. This product will be screened over a 3/16-in. screen, and the undersize will by-pass the stamps, running to the classifiers. The latter will receive the battery pulp also and will deliver sand to tube mills arranged in closed circuit with the classifier. Agitators will be arranged in series for continuous agitation, giving a total time of 55 hr. in the tanks. The solution from the Oliver filter and from the overflow of the thickener preceding it will be clarified and precipitated. The mill has been designed in units, with a view to future enlargement.

Lead and Zinc

Selective Flotation by Horwood's Process.—The Broken Hill correspondent of the Australian Mining Standard, Jan. 15, 1914, states that the successful establishment of the Horwood process of selective flotation at the works of the Zinc Corporation was one of the metallurgical achievements of 1913. The principle of this process is the roasting of mixed lead-zinc concentrates obtained by flotation, whereby the lead particles are slightly sulphatized while the zinc is unaffected. On floating the roasted product the zinc alone floats and the lead remains submerged.

A plant having a capacity of 500 tons weekly has been in operation for over six months, treating current and accumulated slime concentrates. The slimes are first dewatered and washed to remove soluble salts, then lightly roasted in an Edwards furnace, and finally treated again by flotation. Typical actual results from this plant are as follows:

	Zinc, per cent	Lead, per cent	Silver, oz. per ton
Feed to roaster	40.4	14.6	21.4
Zinc concentrate	48.7	5.2	11.6
Lead residue	10.2	44.2	54.6

The grade of the lead is, of course, dependent on the amount of gangue in the feed.

Tests made on Tasmanian ores show that 85 to 90 per cent of the zinc can be recovered as a concentrate assaying 57 to 58 per cent zinc, while the lead will remain with the iron content of the ore. From 75 to 80 per cent of the silver content of the ore and about 90 per cent of the gold will accompany the lead residue.

Tin

Assay of Tin Ores and Concentrates.—In Bulletin No. 113, Institution of Mining and Metallurgy, will be found two papers bearing on methods of analysis of tin ores and concentrates. The first, by **Mr. H. W. Hutchin,** calls attention to the reaction occurring between tin ores and calcium carbonate, when a finely divided mixture is heated under proper conditions. The effect apparently is the formation of calcium stannate, which is readily soluble in hydrochloric acid. This solution can be reduced with nickel and titrated with iodine solution. The author presents many comparisons between Beringer's method and the lime modification, and shows results agreeing very closely. The operation may not be carried out successfully in the ordinary muffle furnace, but it is accomplished in the "tin furnace" described by Beringer in his Text Book of Assaying, or in an apparatus described by the author. Apparently the products of combustion play an important part, and must have access to the charge in the crucible. Alundum crucibles are preferred, but porcelain does well.

The apparatus suggested by the author is as follows: A piece of asbestos mill board, 6 in. in diameter and 1½ in. thick, is perforated in the center with a hole 2¼ in. in diameter. Three iron wire nails 5 in. long are inserted through the board from three equidistant points on the circumference and at a distance of about ⅜ in. from the base. The points of the nails may be covered with asbestos to prevent their oxidation, and the nails can be adjusted to support crucibles of different sizes. A Bunsen burner of large size, ⅝ in. diameter of tube, is used to supply the necessary heat. The crucible to be heated is suspended on the nail points in such a manner that the lower portion is below the board, and the upper portion affected only by radiation from the board. The cone of the flame should envelop the crucible. A large Techlu burner may be used. A charge consists of approximately equal parts of tin ore and calcium oxide, intimately mixed. The lime may be in excess. The reaction is complete in 20 min., with a Bunsen burner, and in 15 min. with a Techlu burner if an alundum crucible is used, or 20 min. with a porcelain crucible. The crucible is covered during the operation. After ignition the charge is brushed out of the crucible, dissolved in hydrochloric acid, reduced with nickel, and titrated with iodine solution.

The second paper on the same subject is by **Messrs. E. A. Wraight** and **P. Litherland Teed,** and consists in an investigation of the Pearce-Low method. In brief this method consists in fusing the finely powdered ore with several times its weight of sodium peroxide in an iron or nickel crucible, dissolving the fusion in hydrochloric acid, reducing with nickel and titrating with iodine solution. The authors investigate the effect of various elements which may be present in ores, and consider various other features of the method.

They conclude (1) that the ore should be ground to at least 100-mesh; (2) that nickel crucibles are superior to iron, as the latter may yield high results by contributing some ferrous chloride in the final titrating solution; (3) the amount of hydrochloric acid in the solution at the time of reduction should be 125 cc., and the bulk of solution should be about 400 cc.; (4) the temperature at titration should be not more than 70° F.; (5) the strength of the standard solution should not be more than 11 g. of iodine and 20 g. potas-

sium iodide in one litre; (6) before titration the calcite that has been added to give a neutral atmosphere should all be dissolved; (7) titanium, tungsten and bismuth interfere seriously and should be removed; titanium by fusion with potassium bisulphate, solution of the fused mass with sulphuric acid and filtration, catching the tin on the filtrate; tungsten also may be removed in a similar manner, or it may be removed by filtration after reduction of the tin solution by nickel; bismuth may be removed at the same time as tungsten, by filtration of the solution after reduction with nickel; (8) nickel should always be used for reduction in preference to iron; (9) in rich ores, zinc, lead, iron, nickel, arsenic, chromium, copper, manganese, uranium, calcium, aluminium, sulphur, fluorine, boron and phosphorus do not interfere.

Recent Chemical and Metallurgical Patents

Iron and Steel

Use of Raw Fuel in Blast Furnaces.—Carbonized fuel such as coke and charcoal is generally employed in all kinds of blast furnaces. The use of raw or uncarbonized fuels has been attempted, but is accompanied with some difficulties, arising from the fact that the carbonization is not effected where most needed. The object of an invention by **Francois Prudhomme** of Vienne, France, is a device for shaft furnaces of all kinds making it possible to use raw fuels in such furnaces. In fact the furnace becomes an apparatus for carbonizing the raw fuel in the upper half and utilizing this fuel in the smelting operation in a lower zone.

Referring to Fig. 1, which is a vertical sectional elevation of a shaft furnace, the device is seen to consist in a number of superposed rings B provided with inclined tuyeres C entering the wall of the furnace and passing through it. These tuyeres and rings are connected through D with the air supply at E. The introduction of air through the tuyeres results in burning sufficient gases to carbonize the raw fuel, which subsequently reaches the level of the boshes at a relatively high temperature.

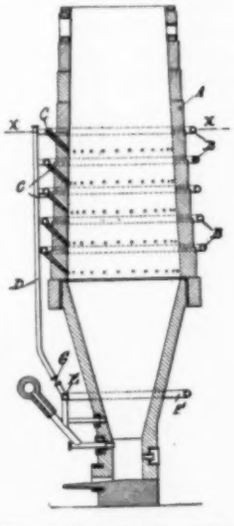


FIG. 1—BLAST FURNACE FOR UNCARBONIZED FUEL

The advantages claimed by the inventor are the elimination of expense necessitated by separate carbonization; the use of the heat of the carbonized fuel, and the collection at the outlet of the shaft furnace of certain by-products. (1,092,168, April 7, 1914.)

Air-Cooled Blast Furnace Stack.—The cooling of thin-walled blast furnaces has usually been accomplished with water circulating through coiled pipes. Objections to this system of cooling are found in the consumption of water, the power required to force the water to the top of the stack, the loss of heat absorbed by the water, and the inability to rapidly control the cooling effect. **Mr. John J. Shannon** of Birmingham, Ala., proposes to utilize air as a cooling medium, particularly in that portion of the furnace above the bosh and crucible. Air is caused to pass through ducts formed by pipes cast in the metal stack-plates, either by a natural draft or forced draft. The cooling system may be so connected with the furnace stoves that the heat absorbed by the air when cooling the stack may be conserved. By this system the air flowing upwardly through the ducts exerts its maximum cooling where most needed, namely, at the bottom of the stack, and tends to radiate heat into the cooler top of the stack and thus maintain more uniform temperature conditions throughout the furnace walls. (1,090,574, March 17, 1914.)

Welding Powder for Iron and Steel.—According to a patent granted to Mr. **E. Ernst Eisengraber**, of Frankfort-on-the-Main, Germany, the following compositon forms a good welding powder:

Red hematite	70	per cent
Coal	22	" "
Flux	8	" "

The flux used is sodium phosphate which favors the production of slag. Other fluxes such as fluorspar, cryolite and the like may be used. The welding powder is convenient for welding soft and hard steel and different kinds of steel and iron. (1,091,312, March 24, 1914.)

Gold and Silver

Aluminium-Precipitation of Cyanide Solution.—The use of aluminium as a precipitant for gold and silver is not new. The metal is usually used in the form of dust, but as this method is open to some objections Mr. **Charles Butters** of Oakland, Cal., has proposed the use of aluminium in granulated or solid form. His process is carried out by passing the cyanide solution through a revolving tube mill containing a charge of aluminium in the form of small irregular bodies. The tumbling of the aluminium in the mill causes the abrasion of small particles and prevents the accumulation of gold and silver precipitated on the surface of the aluminium. The out-flowing solution which carries most of the gold and silver in suspension may be sent to a filter press for the recovery of the precious metals. (1,092,765, April 7, 1914.)

Granulated Zinc Precipitation of Cyanide Solution.—Zinc is used in two forms for the precipitation of gold and silver from cyanide solutions: dust and shavings. Both methods are open to certain objections which Mr. **Charles H. Urquhart** of Newark, N. J., proposes to overcome by using granulated zinc in a tube mill or other revolving drum through which cyanide solution is caused to flow. The granulated zinc is prepared by pouring molten zinc from a height of two or three feet into cold water. The product consists of small, irregular, unoxidized masses of brittle zinc which, when tumbled in the tube mill, break up into still smaller particles favorable for precipitating purposes. The inventor's apparatus is so arranged that the tube mill is at all times filled with cyanide solution so that no air is present. The outflowing solution carrying the precious metals in suspension is passed through a filter press or other suitable means of recovering the gold and silver. (1,090,661, March 17, 1914.)

Zinc

Isherwood Process for Refractory Zinc-Lead Ores.—According to the patented process of Mr. **Percy C. C. Isherwood** of Bushey Heath, England, refractory zinc-lead ores are treated for the recovery of the zinc by roasting, leaching with sulphuric acid, and electrolyzing the zinc sulphate solution. The ore is first roasted under conditions which will yield both zinc sulphate and oxide, with no sulphide remaining. The leaching is carried out in two stages. First, in an open vat with a quantity of solvent less than that necessary for the solution of all the zinc in the ore; second, in

a special form of extractor under pressure with an excess of the solvent. The extractor has been described in this journal, January, 1913, p. 54. The liquor obtained from the extractor is used as the leaching liquor for the first leach of a new quantity of ore. The ore remaining after the complete treatment may be treated for the recovery of any other metals contained. (1,089,412, March 10, 1914.)

Magnetized Roasted Zinc and Iron Ores.—A common method of separating iron and zinc minerals is to roast the ore to render iron magnetic and then subject the ore to magnetic treatment whereby the iron is removed. Owing to the fact that zinc minerals frequently carry combined iron, the magnetic gap between the iron ore and the iron-bearing zinc ore is not as wide as can be desired. In order to increase this gap and make it easier to separate iron and zinc minerals by magnetic separation **Mr. Geo. S. Brooks** of DePue, Ill., has patented a method of treating the ore after it has been roasted and prior to magnetic separation. In brief the process consists in subjecting the ore to the action of producer gas. The chief reaction may be expressed by the following:

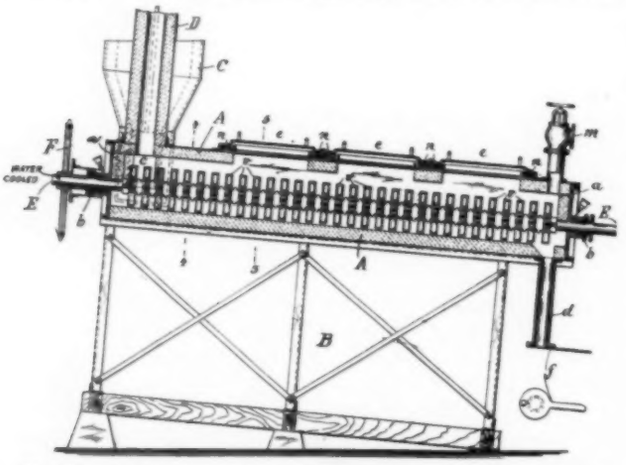


FIG. 2—APPARATUS FOR MAGNETIZING IRON-ZINC ORES

$$3Fe_2O_3 + CO = 2Fe_3O_4 + CO_2.$$

The apparatus for carrying out this process is shown in Fig. 2. It consists of a long U-shaped chamber having a slope in the direction of its length. It is provided with a feed hopper C and discharge hopper *d*. Explosion doors are provided along the roof of the chamber. Producer gas is admitted through the flue D and the waste products escape at the opposite end through *m*. The hot, roasted ore passes through the chamber and is gradually elevated and dropped through the gas by slowly revolving cups *v* which are keyed on the central shaft. (1,090,516, March 17, 1914.)

Ore Cooler

In Fig. 3 is shown, partly in elevation and section, an ore cooler patented by Mr. **Frederick Laist** of Anaconda, Mont. The cooler consists of a drum which is set at an inclination to aid the passage of ore from feed to discharge end. Cooling is effected by a series of pipes placed along the inner surface of the drum, receiving cooling water through pipe P. The drum is provided with water heads at both ends with which the pipes are connected. The water head at the feed end is not a part of the drum but is separated from it by space S. At this end the drum is closed by a plate through which the cooling pipes pass into the water head. The provision of this space permits expansion and contraction to which the drum is subjected. (1,090,549, March 17, 1914.)

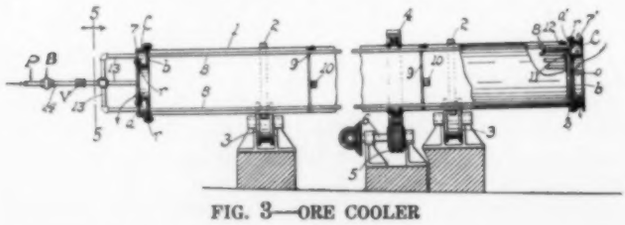


FIG. 3—ORE COOLER

Aluminium

Purifying Aluminium and its Alloys.—The purification of molten aluminium from mechanically entrained impurities resulting from the melting of scrap metal may be accomplished by a flux of sodium chloride and sulphur, according to a patent recently granted to **Mr. Grenville Mellen** of East Orange, N. J. Molten sulphur and salt are thoroughly mixed and cast into rods which are then used to stir the molten aluminium which is to be purified. The sulphur vapors passing through the molten mass carry impurities to the surface where they form a flux with the salt. Additional fluxes such as sodium metaphosphate or zinc chloride can be added to the aluminium. The rod of salt and sulphur may contain 30 to 70 per cent salt. (1,092,935, April 14, 1914.)

An alloy of aluminium, zinc, copper, and silver has been patented by Mr. **William A. McAdams** of Bay Shore, N. Y. The metals are preferably combined in the proportion of 70 per cent aluminium, 26 per cent zinc, 3 per cent copper, and 1 per cent silver. The alloy will not tarnish and possesses great fluidity so that it will take the smallest impressions from a mold. (1,092,500, April 7, 1914.)

Aluminium Solders.—Mr. **Charles F. Grimm** of LeRoy, Minn., has patented a solder which can be applied to aluminium while the metal is cold. It consists of zinc 25 per cent, tin 50 per cent, lead 25 per cent. (1,093,403, April 14, 1914.)

A solder of different formula patented by Mr. **Auguste Cornande** and **Henri de Cruys** of Brussels, Belgium, consists of 52 per cent zinc, 17.5 per cent aluminium, 30 per cent tin and 0.5 per cent nickel. The nickel may be replaced by an equal amount of German silver. (1,092,340, April 7, 1914.)

Alloys

Acid-Resisting Alloy.—An alloy which is said to resist not only the corrosive action of water and steam, but also that of sulphuric and nitric acids, is compounded as follows: Swedish iron 110 parts, nickel 90 parts, copper 1 part, aluminium 4 parts. Ordinary alloys of iron, nickel and copper have been objectionable because of the separation of the metals throughout the mass of the alloy. The inventor of the above formula, Mr. **Edward G. Gleason** of New York City, states that alloys within the proportions given above can be made without the use of any deoxidizing agent, and will be homogeneous and ductile. (1,093,557, April 14, 1914.)

Making Titanium and Other Alloys.—Various methods have been suggested for the reduction of refractory metals like titanium, and the production of their alloys with aluminium and copper. The objection to these methods, however, is they produce only alloys low in titanium, and when high titanium alloys are produced the metal is in the form of grains disseminated through the mass. According to the improved process of Mr. **Ernest Kraus** of Lynn, Mass., alloys high in titanium and other refractory metals can now

be easily produced. According to one method, an intimate mixture of a compound of the refractory metal and a reducing metal, such as aluminium, is fed into an arc formed between a crucible and an electrode. When working thus with mixtures of titania and aluminium it is possible to get alloys containing as much as 94 per cent titanium. By a modified procedure the titania may first be fused in the arc, after which aluminium or copper or both may be added to the fusion. Reduction follows and a copper-aluminium-titanium alloy is produced. (1,089,773, March 10, 1914.)

Metallurgical Furnaces

Channel Furnace for Burning Ore Briquets.—By the ordinary construction, channel furnaces are divided into upper and lower portions by the traveling hearth. The upper portion, in turn, is divided into a

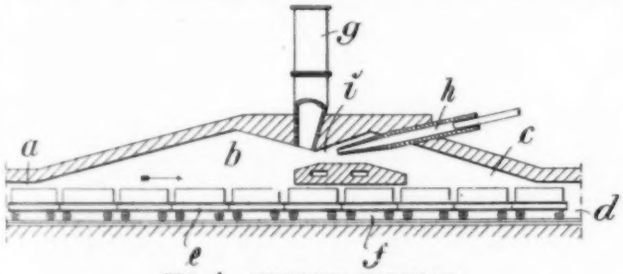


FIG. 4—CHANNEL FURNACE

preheating chamber, a combustion chamber, and a cooling chamber. In order to utilize the heat of the burnt material, the combustion air is usually introduced at the rear of the furnace, in a direction opposite to the travel of the cars comprising the hearth, thereby preheating the air. The object of an invention of **Mr. Arthur Ramén of Helsingborg, Sweden,** is to provide an arrangement within the furnace whereby this preheated air from the cooling chamber will be introduced into the combustion chamber through a series of channels arranged in suitable relation with the gas inlets. In order to impart a suitable speed to this air and the gas with which it mixes, injector nozzles are arranged within the air channels, through which either preheated air or gas can be driven at a high speed.

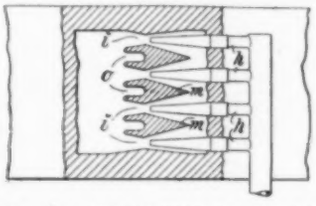


FIG. 5—ARRANGEMENT OF INJECTORS IN CHANNEL FURNACE

Fig. 4 shows a diagrammatic view of a channel furnace in which *a* is the preheating chamber, *b* the combustion chamber and *c* the cooling chamber. The gas inlet is shown at *g*. The tube *h* with the channel *i* forms an injector for introducing air (or gas) under pressure, thereby drawing in air from the cooling chamber *c*. Fig. 5 shows a plan of the arrangement, *m* representing partitions between the tubes *h* and the gas inlets *o*. The channels *i* may be used alternately for gas and air, thereby securing a "gallery" effect. A further advantage of the arrangement is a regulation of the quantities of gas and air over the entire width of the furnace, making it possible to use furnaces of three meters wide instead of 1.5 meters as before. (1,089,868, March 10, 1914.)

The Fitz Gerald Laboratories, Inc., of Niagara Falls, N. Y., will carry on the business of Fitz Gerald and Bennie Laboratories, Mr. P. McN. Bennie having severed his connection with the latter.

Mastic Lining for Acid Tanks

In connection with the operations of the Chile Exploration Company, in Chuquicamata, Chile, there has been developed a new method of lining concrete tanks which are subject to the action of sulphuric acid. Extended reference is made elsewhere in this issue to the nature of the metallurgical operations at Chuquicamata.

The company's copper ores in Chile are handled by the combined sulphuric acid and electrolytic method. After the ore is crushed it is put into large tanks or vats, and then leached with a 10 per cent sulphuric acid solution for forty-eight hours. The solution containing the copper is led through another process for extracting chlorine and then passes to the electrolytic tanks. There the copper is extracted and the remaining solution is then returned to the leaching vats ready for extracting the copper from a new batch of ore.

It can readily be seen that the large tanks required must be such as will withstand sulphuric acid, which, of course, concrete would not do unless provided with a protective lining. Experiments with tanks of various types were made, but in most instances proved failures. It was then suggested that an especially prepared acid-proof asphalt-mastic lining might be used to overcome the difficulties encountered. In coöperation with Mr. E. A. Cappelen Smith, consulting metallurgical engineer of the Chile Exploration Company, experimental tanks, among them one 15 ft. high, lined with Trinidad asphalt mastic, were installed at the research laboratory of the American Smelting & Refining Company, Maurer, N. J. With these tanks there was duplicated as nearly as possible the operation of extracting copper as it is carried out in Chuquicamata.

Under the direction of Mr. Smith various other materials were also experimented with at Maurer, but they all proved unsuitable, with the exception of the asphaltic mastic. It was on the strength of this material having shown no defects or deterioration after a year's test that the Chile Exploration Company has placed the contract for lining with asphaltic mastic some 150 concrete tanks or vats from 15 ft. to 16 ft. in depth and from 120 ft. to 150 ft. in exterior dimensions.

The lining of these tanks in Chile will require from 1250 tons to 2000 tons of asphaltic mastic, which is being prepared here and shipped to Chile. The first cargo of 500 tons was shipped in February, and as soon as it arrives, which will take about three months, as the ship has to go around the Horn, an experienced superintendent and nine mastic workers will be sent to Chile to do the lining of the tanks.

The experimental work at Maurer, the preparation of the asphalt mastic and its application to the concrete tanks was carried out by Mr. Henry Wiederhold, manager of the Vulcanite Paving Company.

Removal of Arsenic from Sulphuric Acid

A new type of dearsenicator for the removal of arsenic from sulphuric acid is now on the market in the United States. It is different in principle from all the dearsenicators at present in use, the majority of which are the tower type. In all of these the sulphuric acid falls vertically over lead grids of various shapes which are so designed as to offer a large area to the action of the precipitant, which is hydrogen sulphide. The maintenance of these is expensive and repairs are frequent.

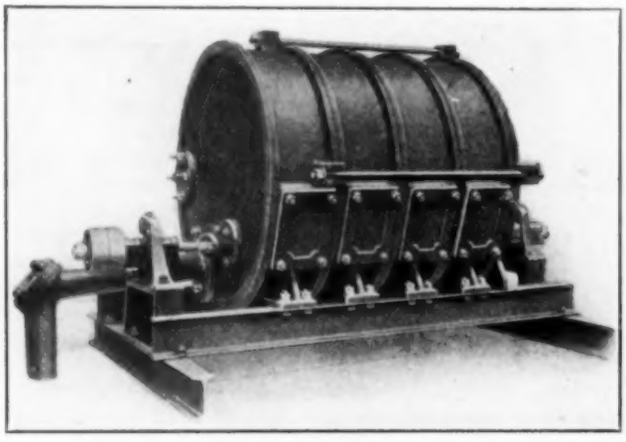
The Davis dearsenicator, which was developed by Davis Brothers, Manchester, England, and an outside view of which is given in the adjoining diagram, consists of an iron drum which is separated into several sections. This is lined completely with a special

enamel which is quite resistant to sulphuric acid up to a temperature of 200 deg. C.

Inside each of these sections an enameled fan is placed so that about one-quarter of the blade dips beneath the level of the sulphuric acid passing through the drum container. These fans are attached to a common shaft and are revolved at between 40 and 60 r.p.m.

The object of the fan is twofold. It is designed to throw the sulphuric acid up as thin sheets and spray which enables the sulphuretted hydrogen to act very completely on the arsenic present in the acid. It also keeps the sulphuric acid, in each particular section, in constant agitation, preventing the settlement of the arsenic sulphide.

The vents in each section are so placed as to enable the sulphuric acid to run from one section to another until it reaches the outlet pipe. From there it is



DEARSENICATOR

passed to filter tanks of special design. Schuler's filter tiles are used. The arsenic sulphide is completely filtered out here. The excess of sulphuretted hydrogen is either absorbed by caustic soda solution or milk of lime.

These dearsenicators are made in all sizes from 20 tons to 500 tons capacity weekly. They are remarkably efficient, giving a production containing from 1.5 parts arsenic per million to 1 part arsenic per million parts sulphuric acid. They will do this starting with an acid containing as high as 0.5 per cent arsenic and the average cost of treating per ton is 30 cents. There are a number of these at present in use in Great Britain, one of which has been in use for over two years without any deterioration or repairs. This type of dearsenicator never chokes up and never requires cleaning.

It also occupies less space than any other type at present in use.

Dearsenicators for sulphuric acid are of a special interest on account of the even more stringent requirements of the recent pure food and drug act.

Acid made from pyrites and treated with hydrogen sulphide in this manner is more pure than acid ordinarily made of sulphur as all the lead, copper, antimony and bismuth are also, of course, completely removed. For this reason the new dearsenicator should be particularly welcome to all who have experienced troubles from the pure food and drug act.

The dearsenicator having a capacity of 200 tons O. V. per week occupies a floor space of about 6 ft. by 3 ft. 6 in. and weighs approximately 3600 lb. The Davis "Trepex dearsenicator" is being introduced in this country by Industrial Research, Inc., 50 East Forty-first Street, New York City.

Improvement in Forging Practice

Notwithstanding the fact that the need for increased efficiency has long been apparent in forge-shop practice, practically all of the progress has been on machine design, and the heating side has been either too lightly considered or entirely overlooked, although in many cases the cost of heating is greater than that of operating the machines. The result has been that the output of the modern machines has been restricted by the inability of the furnace and the man to keep up with them, and worth while savings in cost of manufacture lost. This is particularly true in connection with the heating of small and medium-size work, such as bolt and nut stock, wrench and hammer parts, springs, shears, snips, cutlery, and a great variety of general drop forging and light hammer work.

Forge furnace design and principle of operation have been quite generally befogged by discussions of fuel prices, burner efficiencies, and other details merely incidental to the operation; and too little attention has been paid to the basic principles of proper combustion, chamber provision, protection for the stock, even heating, etc., as well as the more practical question dealing with the protection of the operator.

Efforts have been made to reduce fuel consumption, but in practically all cases the progress in this direction has been at the expense of the quality and quantity of the stock handled, due to the fact that the efforts made to remedy the difficulty have been along the lines of dealing with the effect instead of the cause.

To relieve these conditions the W. S. Rockwell Company, furnace engineers, 50 Church Street, New York,

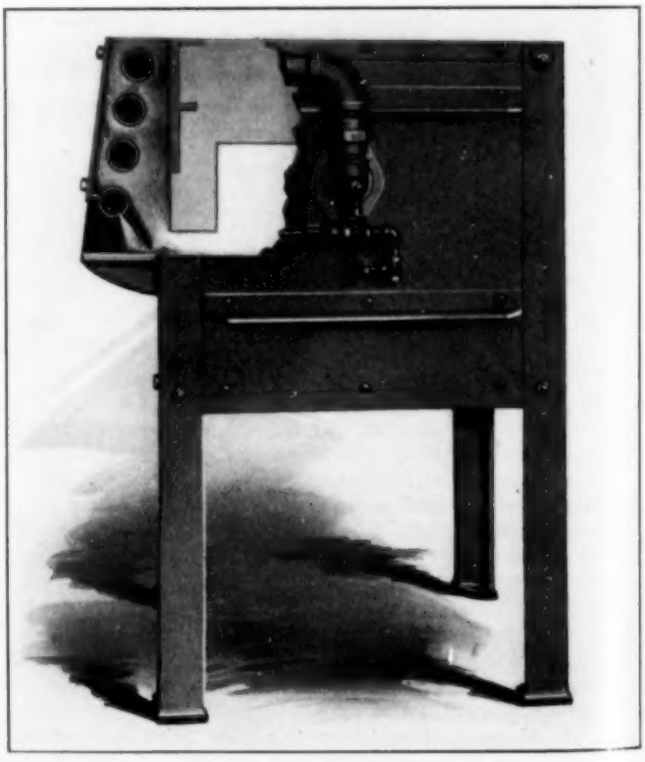


FIG. 1—FORGE FURNACE

have patented and introduced a new type of forge furnace which not only makes it possible for the operator to work to better advantage and keep up with his machines but offers other inducements in the way of decreased operating costs.

The furnace has been successfully tried out under

actual working conditions in the manufacture of a variety of products, and its worth has been demonstrated in competitive operating tests which have led to its adoption in a number of large installations.

The design of the furnace, as shown in the illustrations, involves, among other features, a special economizer shield over the working opening, which recovers a large percentage of the heat ordinarily wasted, and also a novel arrangement of blast which acts as a barrier between the operator and the heat and enables him to work closer to the furnace and handle his material faster and with less effort and discomfort.

In the operation of the furnace the spent gases discharged from the working opening are deflected by

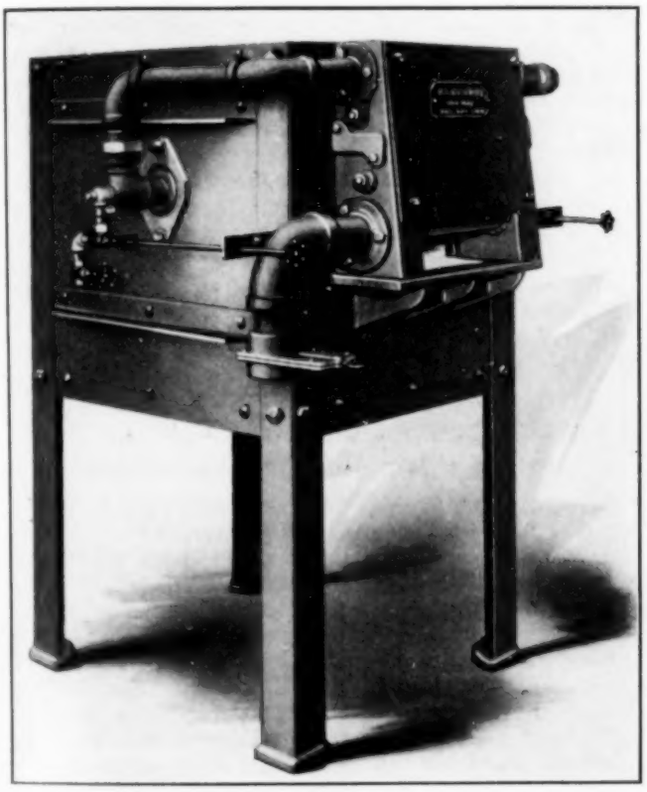


FIG. 2—FORGE FURNACE

the blast sway from the operation and against the tubes and headers of the economizer, through which the air for combustion is circulated, with the result that the air, taking up heat in its passage, is delivered hot into the furnace with the fuel.

The utilization of the waste heat not only means economy in fuel, but in the volume of air introduced into the furnace, which not only tends to decrease the power required to deliver the air, but the amount of oxidation as well.

The provision for combustion is such that the heat is applied uniformly on all sides, and the ill effects of varying temperature or composition of the usual "flame" are eliminated. There is a thorough mixture of the gases, which, with the help of the heated air, makes it possible to maintain clean, soft, soaking heats, which in practice have been found to materially reduce the amount of scale on the stock and in some instances to the extent of doubling the life of the dies.

In front of the working opening is a blast forming a curtain of air under pressure, through which the operator works and the full mechanical effect of the pressure is available all the time, or whether the stock be partly without or entirely within the furnace chamber. This blast not only acts to deflect the waste gases into the economizer, but to protect the operator as well, and it has been found in tests running over a **period** of several months that the more comfortable working conditions enable him to handle his material to much better advantage and in some instances from 60 per cent to 75 per cent more than had previously been heated in the same hearth area.

The advantages of the construction include reduction in consumption of fuel and air, protection for the operator, greater output for the same heating area, reduction in amount of scale, increased die life, as well as cleaner shops and more healthful working conditions for the men, with less heat, smoke, noise and dirt.

Silico-Manganese

The following notes on silico-manganese, made by the Vargöns Company at Trollhättan, Sweden, should be of interest, as this alloy has found considerable use in European steel works as a substitute for ferrosilicon and ferromanganese.

The silico-manganese has the following analysis:

Silicon and manganese together.....90.096 per cent
Phosphorus .....0.030 to 0.070 per cent
Sulphur .....0.010 to 0.015 per cent
Carbon at 17 per cent silicon abt.....2 per cent
Carbon at 25 per cent silicon abt....0.3 to 0.5 per cent
Carbon at 30 per cent silicon abt....0.1 to 0.2 per cent

The proportions of silicon and manganese can be varied so that any alloy containing between 17 to 50 per cent silicon and the manganese between 73 or 79—40 or 46 per cent can be had.

The addition of silico-manganese to the molten steel is done in the same way as for ferromanganese and ferrosilicon.

The advantages claimed for the use of silico-manganese are as follows:

Ferrosilicon and ferromanganese (especially ferrosilicon) add, as well known, to the molten steel a considerable amount of cold iron, which is cooling down the steel at a critical moment; the silico-manganese, on the contrary, is composed almost entirely of manganese and silicon, and therefore the chilling effect is very much reduced.

The manganese is better protected for oxidation on account of the perfect mixture of silicon and manganese in this alloy; therefore the amount of manganese to be added is less than if using ferromanganese. In fact, experience shows a saving of about 10 per cent.

It also follows that it is easier to attain the exact amount of manganese in the steel.

The percentage of carbon in the silico-manganese is low in comparison with ferromanganese, which of course is of great benefit, taking into consideration the recarburizing through the alloy. This is especially important in producing soft steel, and experience has shown that time is saved in making a heat, which means lower costs.

The silico-manganese is made from very pure Swedish manganese ore, very low, as shown by analysis, in phosphorus and sulphur. This has proved to be of great value in producing high-quality steel.

The **American Bridge Co.**, Chicago office, confirms the report that it has the contract for 6000 tons of steel from the International Smelter & Refining Co. to be used in the erection of a new smelter at Miami, Ariz., to cost about $2,000,000. D. A. Welch, Butte, Mont., of the Anaconda Copper Company, is purchasing agent.

Combination Portable Testing Set Using Resistance Thermometers and Pyrometers

For those requiring a temperature measuring instrument for low, intermediate and high temperatures, a recent development by the Hanovia Chemical & Manufacturing Company, of which Mr. Charles Engelhard, 30 Church Street, New York City, is the president, will be of special value, combining, as it does, instruments for widely varying temperatures in a compact, convenient form for portable use. The instruments employed are Heraeus quartz glass resistance thermometers and the well-known Heraeus Le Chatelier pyrometers.

COMBINATION TESTING SET

The resistance thermometers consist of a resistance spiral of chemically pure platinum, which is imbedded in quartz glass, thus insuring no contamination of the resistance spiral by injurious gases and no change in resistance by evaporation. These thermometers are mounted in any form suited to best meet the requirements of the purpose for which they are to be used. Their temperature range is from —330 deg. F. to +1300 deg. F. and an accuracy of ½ of 1 per cent of their scale range is guaranteed.

The Heraeus Le Chatelier pyrometers are too well known to require detailed description here. For use with the combination portable sets, they are mounted in a convenient portable form, suitable for the measurement of temperatures up to 3000 deg. F.

Only one indicating instrument is used which is graduated with two or more scales, depending upon requirements. The thermometer scales may be between any desired limits within the range of the thermometers themselves, and the pyrometer scale is graduated from 32 deg. F. to 3000 deg. F. For example, the indicating instrument could have two thermometer scales, one graduated from 30 deg. F. to 300 deg. F. and the second from 500 deg. F. to 1000 deg. F. and the pyrometer scale from 32 deg. F. to 3000 deg. F.

The sets can be supplied for practically any number of thermometers and pyrometers, and the change from one scale to another and from one thermometer or pyrometer to another is made by the pressing of a button.

The indicating instrument, and all switch and regulating arrangements, are neatly mounted in an oak carrying case, which can be carried inside of an ordinary suit case. The thermometers and pyrometers are also provided with a suitable carrying case.

The special field for these instruments will, of course, be for portable testing work—as for example, in power plant testing, for consulting engineers, demonstrators, etc.

As a practical illustration—in boiler testing the pyrometers could be used in the firebox, flues and stack, and the resistance thermometers in feed water, economizers, condensors and superheaters. One man can take all these temperatures practically simultaneously, and at a point anywhere convenient to himself, as the distance between the thermometers, pyrometers and indicating instrument does not in any way affect the accuracy of the indicated temperatures.

These instruments will fill a long-felt want for a suitable means of accurate testing, where widely varying temperatures must be measured and where requirements demand a compact and easily transportable instrument.

Uses of Asbestos and Its Products in Chemical and Metallurgical Industries

Asbestos holds an unique position among minerals on account of its peculiar physical properties. Since its original discovery it has found a wide variety of industrial applications and has been transformed from a mineral curiosity into an industrial necessity. When treated mechanically it yields soft, white, delicate and exceedingly strong fibers, which can be spun, woven and otherwise manufactured into many useful articles. In addition to its fireproof qualities it is acid-proof and practically indestructible. It also forms a valuable insulator for electrical purposes. Just how extensively asbestos products are used may be gathered from the fact that the H. W. Johns-Manville Co., New York, manufacturers of asbestos products, occupies its own skyscraper business building in New York City (quite close to the Chemists' Club), and maintains forty branch offices in different parts of the United States.

As a heat insulator asbestos finds application in a way that directly affects the cost-sheet. The loss from radiation and condensation due to uncovered or improperly covered pipes, boilers, or furnaces directly affects the coal pile. High-class insulation is absolutely imperative owing to the present high cost of fuel and the growing demand among manufacturers to reduce the unit cost of production to a minimum. Every dollar wasted in fuel consumption detracts from the earning capacity and the profits of the plant. Asbestos insulating materials are the outcome of careful, practical experiments in this field, and have demonstrated through many years of hard service their peculiar adaptability to the purposes for which they are recommended, and the maximum earning power in coal saving. The best insulation is none too good to meet the increasing severity of modern requirements.

Asbestos pipe coverings are made in a variety of forms, such as a mixture of asbestos fiber and magnesia; a light cellular construction of asbestos paper,

and a combination of molded asbestos with a covering of wool felt. Other forms of insulation are made for brine, ammonia, ice-water and cold-water pipes.

It is quite as important to cover boilers, domes, cylinders and large surfaces as it is to insulate pipes. For this purpose asbestos sheets and blocks are used, under conditions where the expansion and contraction of large surfaces would injure cement coatings. Insulating cements of asbestos and magnesia, mixed with water to the consistency of mortar, are applied as coatings over sheets or blocks.

Among the most annoying items of expense in boiler maintenance are the up-keep of fire-brick walls and arches and the cost of delay in cooling down a boiler for repairs. This is largely due to the inefficiency of fire-clay—which heretofore has been the only available bond for setting up fire-brick.

Fire-clay readily fuses and runs, opening up the joints between bricks. In addition to this refractory bricks are porous. Hot gases of combustion enter into the pores of the bricks and into the joints when the fire-clay has fused out, weakening the bricks and eventually causing the whole wall to break down. Cements of asbestos and other refractory materials have been found useful, preventing these conditions.

A plastic asbestos retort cement has found application in gas and chemical works for repairing broken clay and iron retorts and pipes, and cementing fittings, connecting pipes and flange-joints, also for cementing joints in stone, wood and metal. It can be easily applied with a trowel. It hardens rapidly, vitrifies without shrinking when subjected to intense heat and is fire and acid-proof. It is not injured by acids, petroleum oils, etc., and effectually prevents the escape of vapors.

Acid-proof cements are now made which meet other needs in the chemical industry. To the users of acids, either in concentrated or diluted form, the problem is ever present of how to convey them to different points at least possible cost, without the possibility of leakage, resulting in damage to stock and machinery as well as building, also loss of money by waste of acids.

Acids, even in diluted form, will gradually disintegrate and destroy iron and wood, and will in time make a building unsafe.

The storage of acids in bulk and the use of same in tanks is a still further source of trouble because of danger of leakage and subsequent damage. These problems can be solved by the use of a particular form of acid-proof cement.

Of interest to the foundry and machine shop are certain metallic compounds made by the Johns-Manville Co. These are used for smoothing over and filling up blow-holes and sand-holes in iron and steel castings, making pipe joints and stopping leaks in steam, water, gas, oil, ammonia and brine pipe-lines without removing them from position.

Asbestos roofing material is now widely used in the protection of buildings used for chemical, metallurgical and other industrial purposes. In addition to the qualities possessed by other roofing materials, asbestos affords fire protection and acts as a heat insulator. A roofing material composed of asbestos felt impregnated with refined asphalt gives service that makes its use inexpensive when cost of maintenance is taken into consideration.

A great deal of detailed information regarding these and other asbestos products is contained in a long series of catalogs and bulletins issued by the H. W. Johns-Manville Co., Forty-first Street and Madison Avenue, New York City. Any of these publications will be sent on request to applicants who are especially interested in the subject.

New Electric Tachometer

The field of usefulness for recording tachometers includes use in connection with all engines, machinery or revolving shafts wherever information is desired about the rate of speed at which shafting or any other devices are revolving. Some of the most important applications are in connection with engines, turbines, generators, paper machines, blast furnace blowing engines, motors and pumps. Recording tachometers are usually required for continuous service under ordinary shop or mill conditions and for this reason must be made rugged and durable to be thoroughly successful.

A new Bristol electric tachometer of the alternating-current type which is particularly well suited to rough operating conditions in mills, power

ELECTRIC TACHOMETER

plants or shops is being put on the market by The Bristol Company, Waterbury, Conn. Although this is an electric tachometer, no sliding contacts or brushes are used in it and no delicate millivoltmeter movements are required.

Two of the most important features of this electric tachometer which make it particularly strong and durable are the induction magneto and the voltmeter movement. The magneto as shown in the accompanying illustration is of the induction type without any sliding contacts or brushes. The indicating and recording instruments are voltmeters. The indicating instrument is equipped with a Weston pivot jewel-bearing voltmeter movement. The recording instrument is equipped with an improved Bristol voltmeter movement so designed that there is plenty of power available for actuating the recording arm even though the recording pen is in continuous contact with the surface of the chart. In this recorder the movement is mounted on frictionless knife-edge bearings. This movement is equipped with a new patented supporting device for the moving elements designed to eliminate temperature error. This recorder can be furnished for use with either 12-in., 8-in. or 6-in. charts.

The accompanying illustration shows a combination indicating and recording unit which provides an indicating instrument for the operator at his post of duty and a recording instrument for the superintendent or foreman in his office. By the use of suitable lengths of leads, either instrument can be placed at almost any point desired, and more than two instruments can be connected to meet special conditions.

A Novel Branch of Research

"Research work on research apparatus" sounds rather extreme, yet is actually done in Pittsburgh in a very practical way. The demand for a research department came to the Scientific Materials Company in connection with their regular laboratory supply business.

Special apparatus for research is not, however, the only line of work followed by this department, as it also carries on the work which deals with the designing and testing of all new apparatus or improvements in existing types.

This new department really marks an epoch in the development of this company and illustrates how the field of laboratory apparatus has grown. Five years ago the business of supplying laboratories was in itself considered a specialty, yet today it has become necessary to specialize in this same field. In the beginning the demand for different apparatus was comparatively small in each instance, and the natural tendency was to adopt the nearest thing available, at least in part. But the rapid advance in science has caused a demand for a corresponding advancement in scientific apparatus, and the work of meeting this demand now requires a separate organization of its own.

This specialization by means of a separate department for designing and improving apparatus bids fair to add its share to the great progress now being made in chemistry, metallurgy and biology. This is especially so when we consider that many scientific discoveries follow in the path of improvements in the apparatus with which the scientist must work.

In organizing this special work the idea of the late Robert Kennedy Duncan of isolating the men with their problems has been carried out, and this department is relieved of all responsibility of routine, manufacturing, etc. The responsibility of the research department ends after a new piece of apparatus has been designed, tested out and turned over to the sales end of the organization. The many laboratories about Pittsburgh, including the United States Bureau of Mines, the United States Bureau of Standards, the Mellon Institute of Industrial Research and others, were constantly requiring special apparatus in connection with their research work. The men employed in the laboratories, however, had their own problems to solve and preferred to be relieved of the work in connection with the designing and testing of the necessary special apparatus.

The Scientific Materials Company was called upon for this work, and by adding it to the original work which they had been doing in designing and improving apparatus for the regular market, they found that a separate department was necesary to carry on the work successfully.

The department is in charge of a graduate electrical engineer who gives it his whole time and acts as director. He is assisted by a graduate chemical engineer, a sanitary engineer, a mechanical engineer, a pyrometric engineer, a mining engineer, an expert glass blower, and two precision mechanics. At the present time five of these men give their entire time to the research work, and as all the other men are in the regular employ of the company they work from time to time in connection with the others just according to the problems on hand, and also act in a consulting capacity.

When a particularly difficult problem arises, a conference of the staff is called and the problem is presented by the director, and after a general discussion the different ideas and suggestions are obtained. This is very valuable as the staff, on account of their different lines of training, view the problems from as many different angles.

The reference library used in connection with this work is also unique in that it embodies the catalogue file of the import department of the same company, which contains the trade literature of practically every scientific apparatus manufacturer throughout Europe.

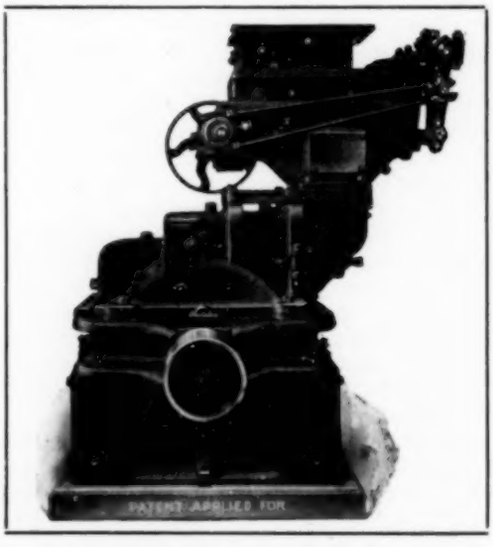
This work has been going on for some time and the first bulletin, "Errors in Bacteriological Incubation," has been issued. This bulletin gives in condensed form an outline of the difficulties encountered, especially in incubators, and tells in detail how they are now overcome in a perfected form of apparatus.

Hammer-Bar Pulverizer

The Sturtevant Mill Company of Boston, Mass., have placed on the market a machine which is claimed to be an improvement on other impact pulverizers both mechanically and in principle of operation. The Sturtevant hammer-bar pulverizer crushes soft and moderately hard materials (up to and including all limestones in hardness). It represents the greatest efficiency in a mill of this class.

The material fed may be as large as 4" to 5" in size, with soft rock, varying to 1½" to 3" for harder substances.

The rock is fed from an automatic feeder which drops it on the heavy hammer-bars of manganese steel which move *upward* to meet it at high velocity (just as the bat meets the flying base-ball). The impact is tremendous

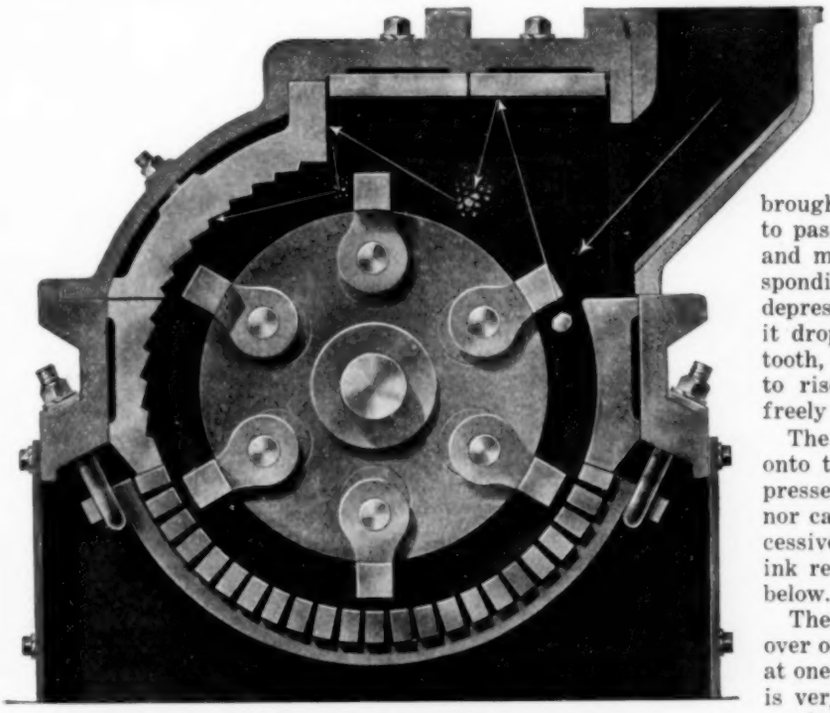


HAMMER-BAR PULVERIZER

and the rock is smashed up against an armor breaking plate, from which it rebounds against another hammer bar swung up against it with the same smashing effect. Thus are dealt, against the rebounding rocks, a succession of terrific blows, and plate collisions (that recur 7200 times a minute), resulting in an immense output of powdered stone.

It should be noted that the smashing action already described represents the *upward* stroke of a bar hammer against rock rushing to meet it. The result attained represents the highest possible efficiency. But when the hammer bars begin their downward path, efficiency is so diminished (the bat chasing the ball strikes a feeble blow) that another plan must be adopted—and the descending hammer bar is now brought close to a corrugated breaker plate where the

greatly reduced broken stone is further pulverized between the high-speed hammer bar and the corrugated plate in close relation thereto. The hammers now pass close to the bar grate, made of the hardest steel, 1¾" deep. The ground rock dashed through the openings of the grate is sufficiently pulverized, and is now violently ejected from the case. This relieves the hammers which otherwise would drag through material already sufficiently reduced. Thus there is no finished rock left to repeat the circuit and waste power.



INTERIOR VIEW OF HAMMER-BAR PULVERIZER

It is clearly seen that as soon as the hammers begin to rush upward again against the incoming rock, they resume their work of rock destruction.

This mill is built extra heavy, and runs with practically no vibration, as it is perfectly balanced, and the hammer bars, held strongly out by centrifugal force, revolve with the sustained regularity of a heavy balance wheel. The bearings are of ample proportion, self-oiling, and dust proof. The hammer bars are of manganese steel, and the screens of the hardest and strongest material obtainable. "Open-door" construction affords immediate access to the interior of the case for inspection, and replacement of hammers, or grates, or screens.

New Recording Pyrometer

A new recording pyrometer, recently perfected by the Thwing Instrument Company of Philadelphia solves the problem of "how to carry water in a bottomless pail," the chief feature of the recorder, from the standpoint of originality, being the new capillary ink-pad.

Fig. 1 illustrates the principle upon which this new ink-pad operates. A horizontal plane of brass is mounted above the drum which carries the chart. In this plane of brass, or ink-pad, is a circular well (C), which is filled with ink, and a V-shaped groove (D), corresponding to the arc through which the needle (E) will travel, as actuated by the thermoelectric force of the thermocouple. This V-shaped groove is open at the bottom, so that the needle (E) may be depressed through the groove upon the chart below.

As the inkwell (C) is filled the ink spreads by capillarity to the extreme end of the groove, so that a film of ink separates the needle, when elevated, and the chart. The depressor arm (G) is attached to a depressor lever mounted on the face of the clock, in the lower section of the recorder case, the clock also being employed to drive the drum carrying the chart. Underneath the depressor lever, on the clock face is a contact wheel having regularly spaced teeth with a gradual rise and abrupt drop.

As the depressor lever travels on the rise of the tooth the depressor arm (G) is raised, tilting the actuating lever (A) so that the depressor bar (B) is brought down upon the needle (E), causing it to pass through the film of ink in groove (D) and make a dot of ink upon the chart, corresponding to the temperature and time. As the depressor bar reaches the summit of the tooth it drops abruptly into the bottom of the next tooth, drawing (A) downward and causing (B) to rise, permitting the needle (E) to swing freely above the groove (D).

The ink will not follow the needle (D) down onto the chart, even though the needle be depressed long enough to make a continuous line, nor can it be jolted through the groove by excessive vibration, but remains a clear film of ink ready for countless records upon the chart below.

The advantage which such a recorder has over one which must return to an inkpad, placed at one side of the chart, for a new supply of ink is very apparent. The frequency of record is much higher with this capillary type of inkpad, as the needle is always in circuit with the thermocouple and is always at the correct position for temperature record, hence it is merely a matter of the frequency with which it is desirable to depress the needle upon the chart.

This type of inkpad has been used for about a year by such gas companies as the Consolidated Gas Co.

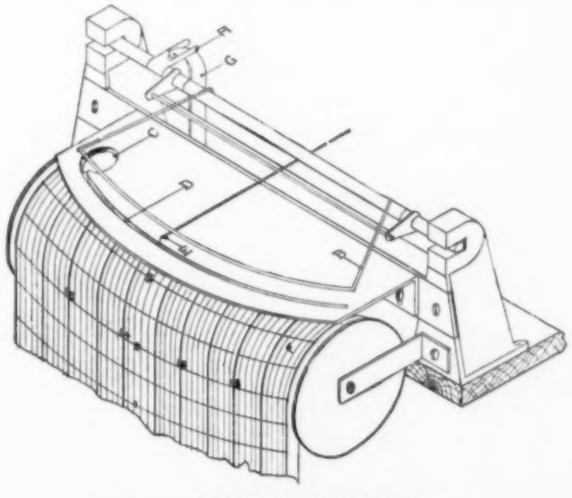


FIG. 1—RECORDER CONSTRUCTION

of N. Y., United Gas Improvement Co. of Phila., for recording temperatures of water gas machines. On the carburetors of such machines it is necessary to secure frequent records of temperature, as the temperature rises and falls very rapidly as the oil is sprayed into the carburetor, the cooling of the gas

as the oil is turned on and its return to the proper temperature covering several hundred degrees in a space of a few minutes. With three records per minute, as made by the capillary inkpad, it was found that practically a continuous line was obtained, each operation being rendered distinct by its minimum and maximum temperature.

Another field in which this type of inkpad is invaluable is in constructing "cooling curve" recorders, for with a high chart speed and ten, fifteen, twenty or even thirty depressions per minute, it is possible to provide a very open, graphic curve showing the behavior of the specimen under treatment. It is also especially valuable in the automatic temperature controlling and recording apparatus, which the Thwing Instrument has recently developed.

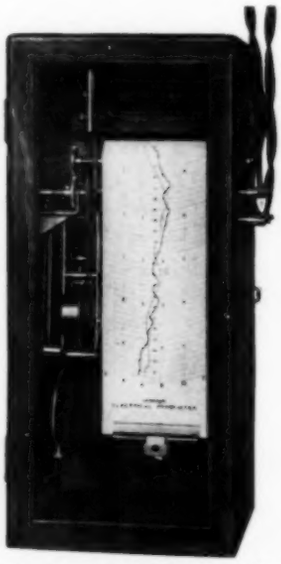


FIG. 2—RECORDING PYROMETER

A complete recorder ready for use is shown in Fig. 2.

Notes

The Chicago Section of the American Chemical Society is compiling a census of the chemical laboratories, chemists, and chemically trained men within a radius of 40 miles of Chicago. Companies and individuals who maintain such laboratories or employ chemists are requested to communicate such facts to the Secretary of the Chicago Section, Mr. D. K. French, 2005 McCormick Bldg., Chicago, Ill.

Electric Zinc Smelting.—The American rights for electrothermic treatment of complex zinc ore are now controlled by Johnson Electric Smelting, Inc., Room 1802, 18 East Forty-first street, New York City. Byron E. Eldred, is president, W. McA. Johnson is first vice-president, Joseph Struthers second vice-president, and Phillip Mallery secretary and treasurer. The designs for a 10-ton unit are about finished, and the furnace is expected to be working in the fall.

The Electrolytic Gas Company has been organized by Mr. E. F. Platt, formerly connected with the Platt Iron Works of Dayton, O., and Mr. C. A. Kurz, Jr., of the Kurz Laboratories. This company has secured the western selling agency of the International Oxygen Company of New York, and it is the intention of the company to proceed with the installation of a number of electrolytic plants of the I. O. C. System for the production of oxygen and hydrogen in different parts of the country.

The American Platinum Works, at Newark, N. J., has issued a new illustrated catalog on their manufactures. The booklet contains also some timely hints on the care of platinum ware, as well as valuable tables of weights and measures.

In drying apparatus of the type made by the Ruggles-Coles Engineering Company, New York, the exhaust gases are at a temperature of about 100° F., so that an exhaust fan may be used. By increasing the speed of the fan an increased capacity of the dryer may be obtained in almost direct proportion. Additional interesting information about dryers is contained in a catalog recently issued by the company.

The Patterson Foundry and Machine Co. states that, contrary to the general belief of the existence of a general business depression, they have been so rushed with orders as to find it necessary to build an addition to their Upper Works at East Liverpool, Ohio. They are also now considering the increase of the capacity of their Lower Works and an increase in their structural and steel plate department. All of the Patterson products are made entirely in the Patterson shops, including all parts of all machines. To take care of their rapidly growing trade in the East they will open shortly a fully equipped New York office. Mr. Edward W. Lawler, formerly with the Abbe Engineering Company for a number of years, will be in charge of this office and represent the Patterson Foundry & Machine Company in New York and adacent territory.

Two new white-metal alloys of silver and aluminum, known as "argental" and "macadamum," are said to possess properties that make them superior to other metals for certain uses. They take a high polish, do not tarnish or corrode, and can be cast or rolled. The alloys are marketed by the North American Selling Company, 120 Liberty street, New York City.

Baker & Company, Inc., of Newark, N. J., have recently added a new factory and office building to their plant. The structure will be devoted to the manufacture of platinum wire, sheet and tubing, as well as crucibles and dishes for chemical purposes. Extensive additions are also planned for the refining and research departments which will occupy the building formerly devoted to the manufacturing department.

The Check to Dampness is the title of an attractive edition of their "Red Book" just issued by Toch Brothers, 320 Fifth Avenue, New York City. It contains valuable data for the architect, engineer and builder who wishes to keep posted on the latest developments in materials for the preservation and decoration of every type of building construction. Toch Brothers for years have been inventors and manufacturers of technical and scientific paints, enamels, varnishes, etc., and this book is replete with data pertaining to materials which are proof against all destructive agencies—acids, alkalies, electrolysis, locomotive fumes, etc., and, in addition, contains authoritative data on the integral waterproofing of dry docks, tunnels, swimming pools, reservoirs; also the treatment of cement floors in warehouses, automobile plants, loft buildings, power houses, public and private buildings.

The Badger Chemical Diary for 1914, issued by the E. B. Badger & Sons Company of Boston, Mass., contains in a very convenient form besides the usual diary, maps of different sections of the United States and illustrated notes on various products of this firm, such as stills, evaporators, vacuum fans, dryers, autoclaves, lead and silver-lined apparatus, etc. Some useful tables are added.

Coal briquets to the amount of 181,859 short tons, valued at the plants at $1,007,327, were manufactured in 1913, according to Edward W. Parker, of the United States Geological Survey. The figures for 1913 show a decrease of 17 per cent in the tonnage of briquets manufactured, but an increase of over 5½ per cent in value over the figures for 1912. Seventeen briquetting plants were in operation during the year, eight in the Eastern States, five in the Central States, and four on the Pacific coast. Seven of these plants used anthracite culm or "fines," five used bituminous or semi-bituminous coal, two used carbon residue from oil-gas works, and the others used mixed coals. Coal-tar pitch is the principal binder employed, eight plants using it. Patented binders were used at five plants.